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Situational analysis study for the agriculture sector in Kenya

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Report

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About CCAFS

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Abstract

Agriculture is central to adaptation and mitigation of climate change. This is well recognized in the *Paris Agreement,* where many developing countries including Kenya prioritized agriculture as one of the critical sectors for the realization of their transformation to climate resilient development pathway. As part of commitment to achieve this, Kenya has embarked in developing its agriculture long-term strategy (LTS) to help define their longer-term agenda to guide near and long-term climate action and planning, while helping to guide updating of successive Nationally Determined Contributions (NDCs). To achieve this, a situational analysis of the agriculture sector was undertaken to provide a baseline**.** Both qualitative and quantitative approaches were employed in the study .These approaches includes document review and key stakeholder consultations which were used to establish the status, comprehensive trends, impacts of climate change, policies and strategies, adequacy of response measures and their coherence to existing policies, climate financing, measurement, reporting and verification, monitoring and evaluation frameworks in the sector in order to evaluate the progress made and identify the existing gaps to be addressed in order to transition Kenya's agriculture sector to low emission, climate resilient development pathway.

This analysis has established that Kenya has made significant the progress it modernizing and transforming it's agriculture sector to an innovative, commercially oriented and competitive sector. This has been achieved through continuous review and operationalization of policies and strategies, enactment of laws and creation of institutions in the different agriculture sub-sectors. Other areas include implementation of policies, legislation, programmes and projects that aim to improve agricultural productivity, increase market access and household income, build social resilience and capacity building.

There is the need of the agriculture sector and climate change that take into consideration emerging dynamics in the achievement of the sector strategic objectives. This includes National Climate Change Strategy, National Climate Change

Action Plan, National Adaptation Plan, agriculture sector transformation and growth strategy, National climate change policy, national climate change act 2016 among others. The analysis has established that for the agriculture to transition to the climate resilient Carbon development pathway, it faces several gaps: lack of cooperation and coordination within and across the sub-sectors at national and county levels, limited technical capacity to fully implement the policies, legislation and programmes and deliver of competitive projects to attract climate finance, lack of well coordinated and elaborate databases with well defined data and knowledge and information sharing mechanisms, weak political will to deliver on the national, regional and international commitment such as Malabo declaration, Africa Agenda 2063 and Sustainable development Goals through spearheading national commitments. Other gaps include very good policies and legislation on paper but not much progress in terms of practical implementation, limited mechanisms to coordinate and align the agriculture devolved and national functions. Therefore, there is need for the national government to full integrate climate change and agriculture actions in its annual budgetary process; strengthen the capacity of the national experts to deliver on competitive programmes and projects to benefit from the international climate finance, especially agriculture projects that have co-benefits on adaptation, fully implement the agriculture and climate change policies, undertake Monitoring and evaluation, Measurement, Verification and Reporting with very transparent and well defined mechanisms and systems. Lastly, the ongoing initiatives in the country provide excellent platform to maximize the contribution of agriculture to low carbon development pathways including the cascading of the CSA Programme to the counties including policies and legislation, the multi-stakeholder platform to consolidate the achievements of different projects by different actors to provide evidence for updating the NDC. Facilitate counties to operationalizse their climate change fund to allow them implement CSA practices.

The sub-sector priority areas for low carbon development pathway include increased access to climate resilience safety net programmes, strengthen the value addition along the agricultural value chain, promote sustainable land management

practices such as water harvesting, soil water management and strengthen the data and knowledge and data sharing platform under GODATA and other relevant platforms. For mitigation, promote the agroforestry, afforestation and re-afforestation programmes in counties, encourage the use of renewable energy including the biogas plants and energy efficient systems for feed management and processing along the value chain.

Keywords

Kenya; sciences; policies; partnerships; agriculture; climate change; food security.

About the author

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Contents

Acronyms

ACMAD	African Centre for Meteorological Application for Development
ACTS	African Centre for Technology Studies
ADB	Africa Development Bank
ADC	Agriculture Development Co-operation
AEZ	Agro-Ecological Zones
AF	Adaptation Fund
AFC	Agriculture finance Co-operation
AFFA	Agriculture Fisheries and food Act
AgGDP	Agricultural Gross Domestic Product
AGNES	African Group of Negotiators Experts Support
AGRA	Alliance for a Green Revolution in Africa
AGRHYMET	Agro-meteorology and Hydrology Regional Centre
AISWAG	Agriculture and Irrigation Sector Working Group
ALFA	Agriculture, Livestock and Food Authority Bill
AMCEN	African Ministerial Conference on Environment
AMESD	African Monitoring of the Environment for Sustainable Development
ANAF	Aquaculture Network for Africa
ARC	African Risk Capacity
ARNS	Africa Regional Nutrition Strategy

ASAL	Arid and semi-arid Lands
ASAL-APRP	Arid and Semi-arid lands- Agricultural Productivity Research Project
ASDSP	Agricultural Sector Development Support Programme
ASGTS	Agriculture Sector Growth and Transformation Strategy
BGI	Blue Growth Initiative
CAACS	Catchment Area Advisory Committees
CAADP	Comprehensive Africa Agriculture Development Programme
CBD	Convention of Biological Diversity
CBI	Climate Bonds Initiative
CBK	Central Bank of Kenya
CCAFS	Climate Change, Agriculture and Food Security
CCCM	Canadian Climate Center Model
CCR	Carbon Climate Registry
CDM	Clean Development Mechanism
CIAT	International Center for Tropical Agriculture
CIDP	County Integrated Development Plans
CIFA	Committee for Inland Fisheries for Africa
COMESA	Common Market for Eastern and Southern Africa
CRMA	Climate Risk Management and Adaptation Strategy
CSA	Climate Smart Agriculture
CSOs	Civil Society Organizations

DMC	Drought Monitoring Centre
DRM	Disaster Risk Management
EAA	Ecosystem Approach to Aquaculture
EACCMP	East Africa Community Climate Change Master Plan
EMCA	Environmental Management and Coordination Act
EO	Earth Observation
EPAs	Economic Partnership Agreement
ERS	Economic Recovery Strategy
ESCR	Economic, Social and Cultural Rights
FAFS	Framework for African Food Security
FAO	Food Agriculture Organisation
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FNSP	Food and Nutrition Security Policy
FPCM	Fat and Protein Corrected Milk
GCM	General Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GESIP	Green Economy Strategy and Implementation Plan
GFDL	Geophysical fluid Dynamics Laboratory
GHG	Green House Gas Emissions
GODAN	Global Open Data for Agriculture and Nutrition

GOK	Government of Kenya
GPC	Global Producing Centers
ICCA	Institute of climate change adaptation
ICESCR	International Covenant on Economic, Social and Cultural Rights
ICO	International Coffee Organization
ICPAC	IGAD Climate Prediction and Application Centre
ICT	Information and Communication Technology
IFPRI	Intergovernmental Authority on Development
IGAD	International Food Policy Research Institute
ILRI	International Livestock Research Institute
INDC	Intended National Determined Contribution
IOTC	Indian Ocean Tuna Commission
KALRO	Kenya Agricultural and Livestock Research Organization
KBA	Kenya Bankers Association
KCCF	Kenya Climate Change Fund
KCSAFP	Kenya Climate Smart Agriculture Framework Programme
KCSAIF	Kenya Climate Smart Agriculture Implementation Framework
KCSAS	Kenya Climate Smart Agriculture Strategy
KEFRI	Kenya Forestry Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
KEPSA	Kenya Private Sector Alliance

KJWA	Koronivia Joint Work on Agriculture
KLIP	Kenya Livestock Insurance Project
KMC	Kenya Meat Commission
KNAP	Kenya National Adaptation Plan
KNBS	Kenya National Bureau of Statistics
KNCCS	Kenya National Climate Change Strategy
KRDS	Kenya Rural Development Strategy
LDCF	Least Developed Countries Fund
LVFO	Lake Victoria Fisheries Organization
MDBs	Multilateral Development Banks
MESA	Monitoring of Environment for Security in Africa
MLHUD	Ministry of Lands, Housing and Urban Development
MOALF&C	Ministry of Agriculture, Livestock, Fisheries and Cooperatives
MRV	Measurement, Reporting and Verification
MTP	Medium Term Plan
NAIPs	National Agriculture Investment Plans
NALEP	National Agriculture and Livestock Extension Programme
NAMA	National Appropriate Mitigation Actions
NAP	National Adaptation Plan
NAPs	National Action Programmes
NBSAPs	National Biodiversity Strategies and Action Plans

NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NDCs	National Determined Contributions
NDMA	National Drought Management Authority
NEPAD	New Partnership for Africa’s Development
NGOs	Non-governmental Organizations
NIMES	National Integrated Monitoring and Evaluation System
NLC	National Land Commission
NSE	Nairobi Security Exchange
NSNP	National Safety Net Programmes
ODA	Oversees Development Assistance
PES	Payment of Ecosystem Service
PESTELI	Political Economic Social Technological Environmental Legal and International
PPR	Pestes des petits ruminants
RCCs	Regional Climate Centers
RECs	Regional Economic Committees
RPLRP	Regional Pastoral Livelihood Resilient Project
RVF	Rift Valley Fever
SADC	Southern African Development Community
SCCF	Special climate Change Fund

SDG	Sustainable Development Goals
SEI	Stockholm Environment Institute
SFDRR	Sendai Framework for Disaster Risk Reduction
SLEEK	System for land-based Emission Estimation in Kenya
SLM	Sustainable Land Management
SMS	Short Messaging System
SNC	Second National Communication
SPA	Strategic Priority on Adaptation
SSA	Sub-Saharan Africa
STISA	Science Technology Innovation Strategy for Africa
SWIO	South West Indian Ocean
SWIOFC	South West Indian Ocean Commission for Fisheries
TSP	Target Setting Programme
UNCBD	United Nations Convention on Biodiversity
UNCSD	United Nation conference on Sustainable Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
USAID	United States Agency for International Development
WB	World Bank
WMO	World Metereological Organisation

WRMA	Water Resource Management Authority
WRUAs	Water Resource Users Association
WTO	World Trade Organization
WWF	World Wildlife Fund

Introduction

Context

Kenya is an eastern African country, straddling the equator, between latitudes 4° N and 4° S, and longitudes 34° E and 41° E; bordered on the east by Somalia and the Indian Ocean, on the north by Ethiopia and Sudan, on the west by Uganda and on the south by Tanzania. The country has a total area of 582,646 square kilometers with the land covering 571,466 kilometers square. Kenya has diverse climates with a mean annual rainfall ranging from less than 250 mm in arid and semi-arid areas which cover over 80% of the country's landmass, to 2,000 mm in high potential areas.

The agriculture sector which comprises of crops, livestock, fisheries and agroforestry remains one of the main drivers of socio-economic development in Kenya and offers great potential for growth and transformation. The sector currently contributes about 51% of Kenya's Gross Domestic Product (GDP) (26% directly and 25% indirectly). It accounts for over 65% of exports and employs more than 40% of the total population and over 80% of the rural population (ASTGS, 2018). The sector is dominated by smallholder rain-fed production farming systems of between 0.2 and 3 hectares, which account for 78% of total agricultural production and 70% of commercial production (World Bank, 2015). Despite the contribution of agriculture to the local and national economies, it is yet to realize its full potential due to various non-climatic and climatic factors. These include: poor land use practices; low levels of investments; limited access to factors of production namely inputs, credit, technologies, markets; that are fundamental for inclusive growth; limited value addition; and weak institutional coordination (Amwata *et al.,* 2019;GoK, 2019;AGRA, 2018). This is exacerbated by climate change (NCCAP, 2012).

Climate change is threatening food production systems and therefore the livelihoods and food security of millions of Kenyans who depend on agriculture. Climate change is adversely affecting Kenya through increased temperatures, erratic rainfall, increased frequency and intensity of droughts and floods. For example, in

2007 about 650,000 people needed food aid and the number rose to 3.8 million in late 2009 and 2010 as a result of devastating prolonged droughts experienced during that period (Amwata *et al.,* 2015). Analysis of long term climate data shows that average annual temperatures have risen by about 1.0°C since 1960 and are projected to increase by 1.0-2.8°C and 1.3-4.6°C by the 2060s and 2090s, respectively (NCCAP, 2012). Precipitation in Kenya has generally remained the same in recent decades, with only a slight decrease experienced, likely due to a reduction in precipitation during extended rain periods.

Agricultural production will be substantially affected by the expected changes in rainfall patterns, temperature rise and occurrence of extreme weather events due to the excessive rainfed dependence of the sector. Future projections of annual rainfall are uncertain and range from a 6% decrease to a 26% increase from the 1970-1999 average by 2060. The amount and timing of rainfall throughout the year is also projected to change, with increased inter-annual variability. Kenya has experienced extreme events of droughts, floods, and storms. Droughts have increased in frequency and extent in recent decades and now impact areas that were unaffected historically. Since 1993, Kenya has declared six national disasters due to droughts. Projections indicate an increase in the frequency and duration of droughts and a greater amount of annual precipitation falling during heavy rainfall events (USAID,2012). Consequently, it is projected that the country will continue experiencing extreme weather events especially droughts and floods at the cost of about 3% of GDP per year by 2030 and nearly 5% by 2050 (KCSAIF, 2018). Fisheries will also be affected through physical and biological changes associated with climate change such increase in water salinity, low primary production and ocean acidification (Mohammed and Uraguch, 2013).

Over the years, the Government of Kenya has put in place policies that support agricultural development and response to the effects of climate change. These include: the Kenya Climate-Smart Agriculture Implementation Framework Programme (2018-2027); National Livestock Policy 2015; National Oceans and Fisheries Policy 2008; National Agricultural Research System Policy, 2012; Strategic Plan for Agricultural and Rural Statistics 2015-2022; National Agricultural Sector

Extension Policy 2011; and the Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019 – 2029. Others are the National Climate Change Policy (NCCP) 2018; National Adaptation Plan (NAP) - 2015-2030; National Climate Change Response Strategy (NCCRS); and Nationally Determined Contributions (NDCs).

This report presents findings of analytical assessment of the current status and trends of the agriculture sector in Kenya and identifies opportunities to transform the sector towards low carbon and climate resilient development pathway. It also analyses the extent to which the existing agriculture policies and strategies have responded to challenge posed by climate change. The report is organized into ten (10) chapters:

- Chapter 1 gives the introduction highlighting the rationale, methodology and limitations the study.
- Chapter 2 presents the status and trends of the agriculture sector.
- Chapter 3 discusses the impacts of climate change on agriculture and adaptation response measures.
- Chapter 4 discusses the mitigation potential of the agriculture sector.
- Chapter 5 examines the enabling policy environment.
- Chapter 6 deals with research, data and information management.
- Chapter 7 deals with governance and performance measurements.
- Chapter 8 provides the transformation agenda towards low carbon climate resilient development pathway.
- Chapter 9 examines finance and investments in agriculture.
- Chapter 10 provides the conclusion and recommendations.

Methodology of the study

This study adopted a composite of qualitative and quantitative methods. The qualitative methods included the review of documentation and interviews while the quantitative methods included observations, semi-structured questionnaire and scoring.

Data collection

Desk review

The desk review included evidence collection through analytical examination and performance assessment of agriculture sector and climate change policies, programmes and projects. Review focused on: i) obtaining data on status and emerging trends and lessons in the agriculture sector taking into account its sub-sectors for the period 2000 - 2010 and 2010 - 2020. This included information on the agriculture values chain and production systems including contribution of agriculture and its sub-sectors to National GDP, gross national income, the contribution of agriculture in relation to the service and industrial sector. Further data was collected on trends on individual crop production levels (acreage, quantity and value), livestock numbers and related production trends for livestock products such as milk, meat, skins and hides; ii) data on impacts of climate change on the agriculture sector; the current adaptation and mitigation responses in the different agriculture sub-sectors and how these impacts have influenced these sub-sectors in terms of production levels and economic terms; iii) information on financial resources and investments on in the agriculture sector in the country; iv) information on existing adaptation and mitigation measures, action plans, relevant policy and legal and institutional structures to indicate their relevance adequacy, gaps and opportunities for improvement in the agriculture sector.

Four overarching sources of information were used for this purpose: a) policy, strategy and framework documents by relevant national and county agriculture ministries, departments and actors including regional and global agricultural institutions relevant to Kenya; b) evaluation of research publications ; c)review of studies on agriculture and climate change and; d) questionnaire and interviews with national stakeholders (MOALF&C, Ministry of Environment and Natural Resources (MENR), Kenya Marine Fisheries Research Institute (KMFRI), Kenya Forestry Research Institute (KEFRI), Kenya Agriculture, Livestock, Research Organization (KALRO), Kenya Private Sector Alliance (KEPSA), Africa Group of Negotiators Experts Support (AGNES) and Kenya Association of Manufacturers (KAM) among others) and regional and international stakeholders (African Union Development Agency (AUDA-

NEPAD), World Wide Fund for Nature (WWF), International Livestock Research Institute (ILRI), Food and Agricultural Organization (FAO), USAID and AfDB. The secondary data sources also included continental and international policy documents, strategy papers, declarations and conventions.

Primary data collection

Individual experts and policy analysts were sampled for key informant interviews across different government institutions, private sector and civil society organizations implementing different agriculture sub-sector policies, programmes and projects. The institutions include: ACTS, AGNES, KAM, KEPSA, WWF, ILRI and FARA. They were purposively sampled based on their engagements and experiences with regards to agriculture and climate change issues. The key informants provided complementary information and their opinions on production trends of major crops, livestock, fisheries and forestry enterprises and possible reasons for the trends; current efforts (policies, programs, actions plans) in place to address climate change, implementing institutions, coordination mechanisms, challenges, gaps and opportunities.

Data analysis and integration

Both primary and secondary data were analyzed to provide a better understanding of the situation in the agriculture sector in the country. Analytical approaches, both descriptive and inferential approaches were used to examine and show the current status and trends in each sub sector of agriculture and the production resources; identifying challenges, successes, and opportunities to catalyze transformation of the sector. The Political Economic Social Technological Economic Legal Institutional (PESTELI) analytical framework (Table 1.1) was adopted and used to analyze macro and sectoral policies and the country’s responsiveness to climate change. This analysis also assessed how these specific components are interacting and influencing each other in the wider agriculture sector in Kenya. The following diagram illustrates the application of the analytical framework in terms of the components and their respective elements.

Table 1.1. Components of the pestle analysis.

Components	Examples of key elements
Political	Governance system; tax policy, labor laws, political stability, corruption, Parliament; ideology; foreign policy; international alignments; tariffs, trade restrictions, mass media pluralism; business environment
Economic	Market liberalisation; economic growth in sectors – agriculture, industry, services; value chain activities; export; foreign currency exchange rates, inflation rates and interest rates
Social	Demographics (population growth rate, age distribution), cultural trends; norms; attitudes, literacy levels, poverty levels
Technological	Production of goods and services; machinery and plants; automation; research and development; emerging technologies – ICT, robotics, transport systems
Environmental	Pollution of ecosystems; GHG emissions; climate change; forest degradation; deforestation; desertification; agro-ecologies
Legal	Laws; LIs; EIs; constitution; Judicial systems; Intellectual Property
Institutional	Public and private establishments; ministries; departments and agencies; NGOs; civil society; linkages, collaborations and partnerships

A multi-level governance analysis was conducted to determine how at the regional, national and sub-national governance levels, policy and programme activities have contributed to positive impacts in the agriculture sector, including lessons learnt on the gender and youth dimensions. The analysis also examined the impacts in the different agro-ecological zones and the vegetation types. The results from content analysis and performance ratings were integrated and used to inform the report.

Stakeholder engagement

The stakeholder engagement was undertaken through consultations with various actors across the agricultural value chain. Those consulted range from ministries, Departments and Agencies (MDAs), research organizations, private sector and civil society organizations (CSOs).

Limitations of the study

The study was undertaken at the time when the country was under lockdown as a result of the COVID-2019 pandemic leading to restricted and limited physical engagements with the key informants. However, every effort was made to virtually reach out to the key informants through email, *WhatsApp*, telephone, zoom meetings, and Skype calls. Another limitation relates to accessing the relevant documents and the accuracy and reliability of data. This was mitigated by checking with published official government documents and peer reviewed publications. In-depth key informant interviews provided complementary information to fill any data gaps.

Status and trends of the agriculture sector

Overview

Agriculture is a major driver of Kenya's economy and food systems. It is a major source of livelihood for the majority of the people in terms of food security, economic growth, incomes, employment creation, and foreign exchange earnings (ASDP, 2010; ASTGS, 2018).The sector comprises of four subsectors: crops, livestock, fisheries and agroforestry contributing about 33% of the total Gross Domestic Product (GDP) accounting for 80%, 15%, 2% and 3%, respectively of sectors' GDP (GoK, 2018).The sector also provides about 60% of informal employment and about 65% of exports for foreign exchange earnings. Further, over 65% of the populations that live in rural areas derive their livelihood from farming and its associated enterprises along the value chain (Amwata *et al.,* 2015; ASTGS, 2018). Households that are exclusively engaged in agriculture contributed 31.4% to the reduction of rural poverty, and agriculture remains the largest income source for both poor and non-poor households in rural areas (World Bank, 2019).

Agricultural production in Kenya is largely rain-fed and dominated by smallholder farmers whose land holding is between 0.2-3.0 hectares; accounting for about 75% of the total agricultural output and 70% of the marketed agricultural produce. They also produce 70% of the maize, 65% of the coffee, 50% of the tea, 80% of the milk, 85% of the fish and 70% of the beef and related products in the country (KBA, 2018).The country's population has increased significantly from 11 million in 1970 to 39.5 million in 2011 and 47 million in 2019 and it is projected to double by 2039 (KNBS, 2017).While the country has made significant progress in the last three decades to build its macro-economic foundation for agricultural transformation, the sector is yet to realize its full production potential due to several factors that include climate-related shocks such as drought, floods and pest and diseases.

Contribution of agriculture to the economy and food security

Agriculture is a major driver of Kenya's economy and food systems. It is a major source of livelihood for the majority of the people in terms of food security, economic growth, incomes, employment creation, and foreign exchange earnings (ASDP, 2010; ASTGS, 2018). The agriculture sector which comprises of crops, livestock and fisheries contributes about 51% of Kenya's Gross Domestic Product (GDP) (26% directly and 25% indirectly). The sector accounts for over 65% of exports for foreign exchange earningsand employs more than 40% of the total population and over 80% of the rural population (ASTGS, 2018). Households that are exclusively engaged in agriculture contributed 31.4% to the reduction of rural poverty, and agriculture remains the largest income source for both poor and non-poor households in rural areas (World Bank, 2019).

Cultivated areas in Kenya occupy about 5 million hectares (ha) of land (**Figure 2.1**). The major food cereals grown in Kenya include maize, wheat and rice. Maize is Kenya's main staple food crop for about 90% of the population in Kenya[i] and is also a key component of feedstuff for livestock. Other food crops include beans, roots and tubers (cassava, potatoes), millet and sorghum. Industrial crops include sugar, pyrethrum, cotton, tobacco, and sisal, while major export crops include tea, coffee and horticulture.

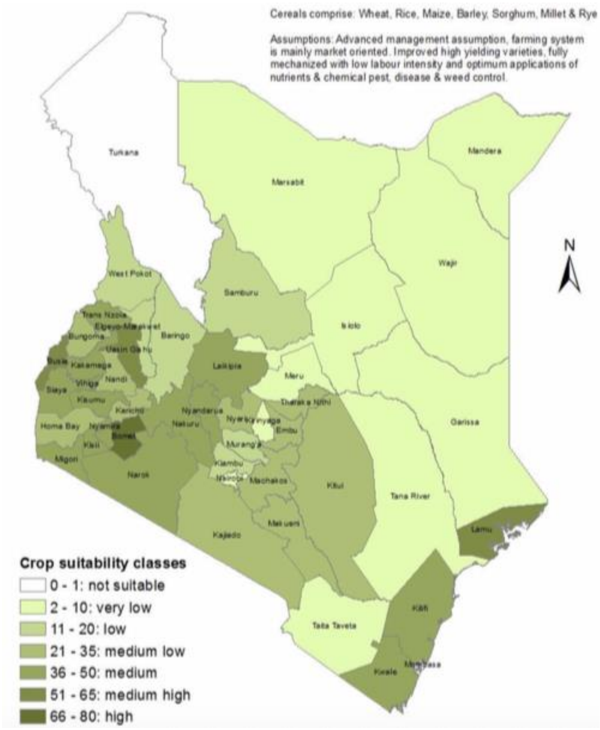


Figure 2.1. Map of land suitability for rainfed cereal crops in Kenya [ii]

Kenya's agriculture[iii] is predominantly small-scale farming where production is carried out on farms averaging 0.2–3 ha. The medium and large scale farms account for about 2% of the holdings, but cover about 54% of the area farmed. The small-scale farms account for 75% of the total agricultural output and 70% of marketed agricultural produce.

Over the last four decades, the country has generally experienced positive growth in agricultural output but has often not managed to achieve national food self-sufficiency. As a consequence, the country experiences episodic food deficits and in a number of cases, acute food shortages. The net deficit in staple foods has been met mainly through annual food imports. This is partly due to over-reliance on rainfed agriculture (98%), which results in recurrent crop failures due to vagaries of weather and climate change.

Status and trends in agriculture sub-sectors

Crop sub-sector

The crops sub-sector is categorized into three, namely, food crops, industrial crops and horticulture as described below.

(a) Food Crops: The main food crops include: cereals (maize, wheat, sorghum, rice, millet); pulses (beans, pigeon pea, cowpea, chickpea, green grams); and, roots and tubers (sweet potato, irish potato, cassava, arrow root and yam). The staple crops are maize, rice, wheat, sorghum, potato, cassava, vegetables and beans. For the period 2000-2010, the average hectarage under beans production was 856,561 hectares (ha) with the lowest being recorded in 2008 at 641,936 ha. The area under beans increased by 31.3% to 1,124,48 ha between 2011-2018. Also, the average area under maize for the period 2000 - 2010 was 1,692,898ha and has increased by 27% to 2,150,065 ha in 2010 to 2018 period. Other food crops that increased their area under cultivation include millet whose area increased from 104,782 ha in 2000 to 2010 period to 119,9762ha, giving an increase of 14.3%. The area under rice also increased by 77.3% to 28,747 ha in 2011-2018 period from 16,212 ha in 2000 - 2010 period. The area under sorghum production increased by 46%during the period 2011 – 2018. Area cultivated under cassava decreased by 0.08% over the same period. Figure 2.2 presents the trends in production of some of the major food crops including maize, beans, millet, sorghum, rice and cassava in terms of hectares harvested in hectares for the period 2000 – 2018.

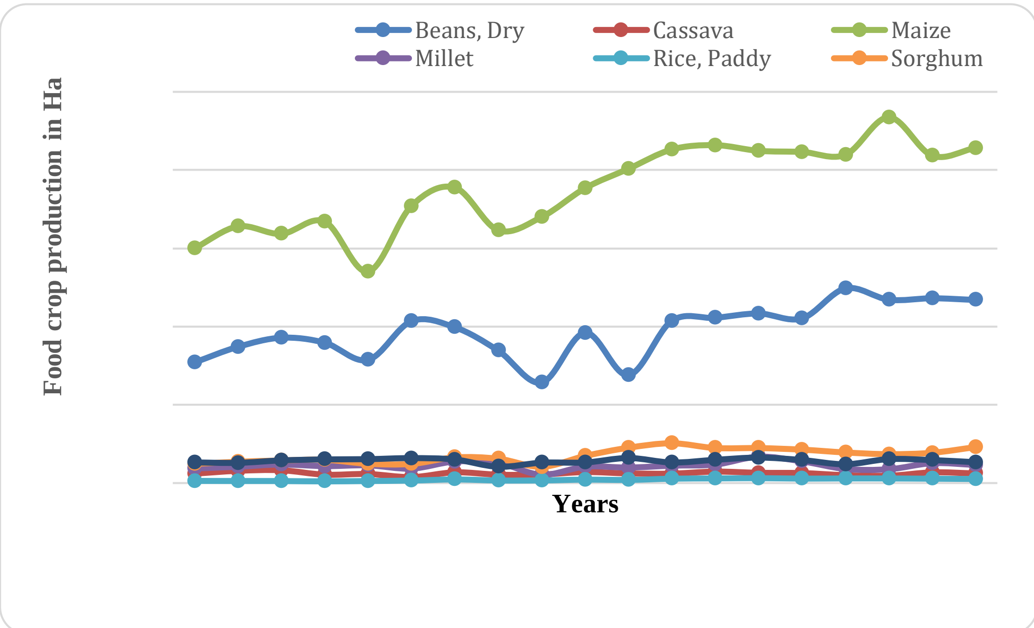


Figure 2.2. Food crops hectarage harvested from 2000 - 2018. Source: KNBS,(2000-2018); Faostats (2000-2018).

The different food crop production levels in tonnes over the 2000 - 2018 period is shown in Figure 2.2. Maize and beans production have shown an increasing trend but with declines in 2004 and 2007. In 2002, maize production was 2.4 million tonnes, which increased to 3.2 million tonnes in 2006 but this reduced to 2.9 million tonnes in 2007. After which its production has increased steadily to peak in 2016 but declined in 2017, which was an election year in the country. Maize production increased by 26% from 35.4 million bags in 2017 to 44.6 million bags in 2018. Production of beans increased from 481,225 tonnes to 531,800 tonnes, while roots and tubers increased from 1.1 million tonnes to 1.8 million tonnes over the same period. For food crops such as cassava, rice, millet, sorghum and wheat, their production has shown a gradual increase over the 2000 to 2018 period with exception of the year 2008, which was marred with postelection violence, displacing some the farmers.

The average yield production of crops yield per kg/ha for the period 2000 -2010 to 2011 - 2018 period shows an increase in yields for most food crops (Figure 2.3). Cassava, millet, beans, paddy rice, maize and sorghum had an increase in yield of 47.6%, 41.9%, 36.5%, 24.6%, 4.8% and 0.4%, respectively during the period 2011 - 2018. However, wheat experienced reduction in yields by 12.4% during the same period.

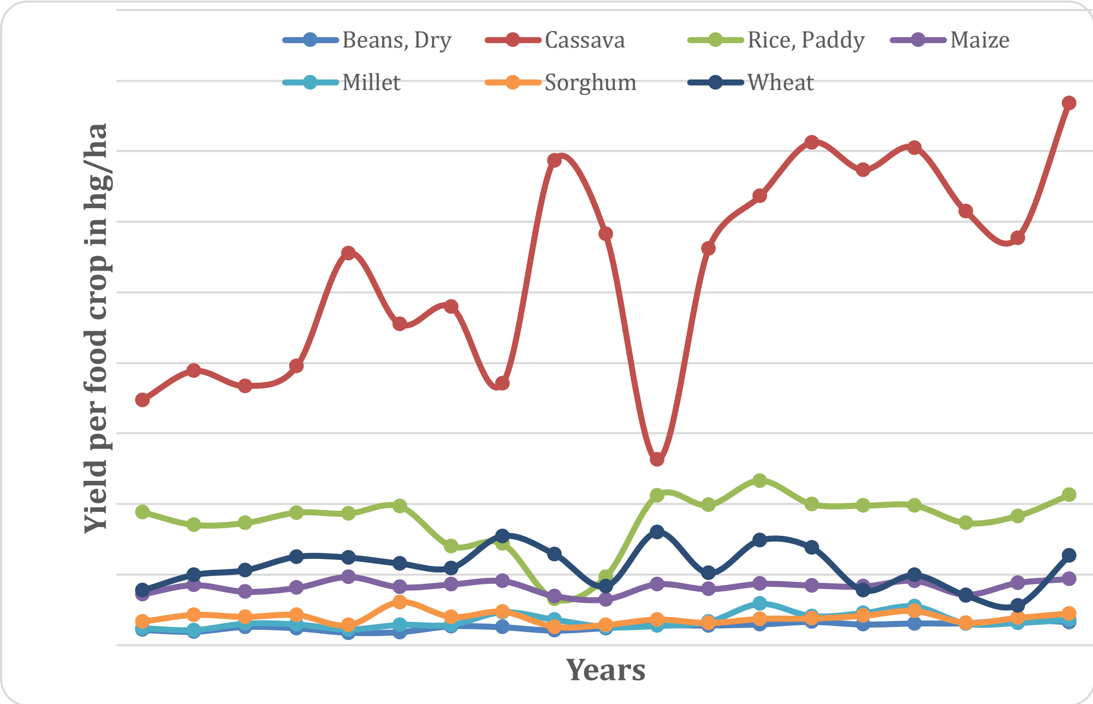


Figure 2.3. Yield production of the selected food crops in Kenya, 2000-2018; Source: Faostats 2000-2018; KNBS, 2010-2018.

The cereal yields have varied greatly from 1,375kg/ ha in 2000 to 1,474 kg/ ha in 2017 (Figure 2.4). The lowest cereal yields were reported in the year 2009, where the yield was 1,243kg/ha while the greatest improvement was reported in the year 2010, where the yield increased by 37.5% of the 2009 values. Similarly, the highest reduction in yield was noted in 2016, where the yields reduced by 21.97% of the 2015 values (Faostats, 2017; KNBS, 2005-2017). The periods of reduced yield production was observed it was attributed to poor climatic conditions including erratic and low rainfall levels. The only exception was in 2008 where the low yields were as a result of post election violence that struck the country after the 2007 elections. Figure 2.4 show the cereal yield in kg/ha. The production levels of the different food crops in tonnes for the period 2000-2018 is shown in Figure 2.5.

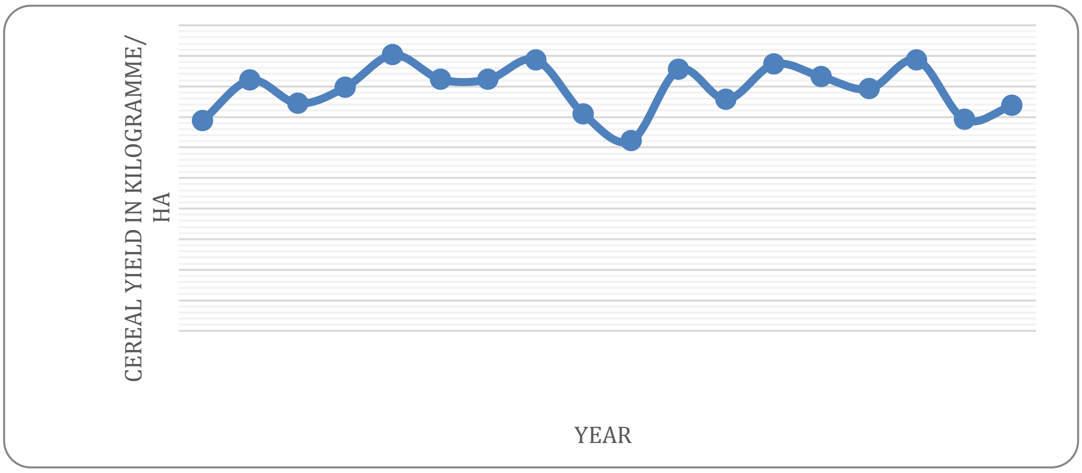


Figure 2.4. Cereal yield in kilogram/ha (2000 - 2017; source: Faostats, 2000-2018; KNBS, 2010-2018.

Table 2.1: Average yield production in hg/ha for selected food crops for the period 2000-2010 and the period 2011-2018

Period	Dry Beans	Cassava	Rice paddy	Maize	Millet	Sorghum	Wheat
2000-2010	4,577	88,905	32014	16173	5832	7758	23357
2011-2018	6,249	131,207	39885	16951	8274	7787.25	20460
Average (%) change	36.5	47.6	24.6	4.8	41.9	0.4	-12.4

Source: Faostats 2000-2018; KNBS, 2010-2018

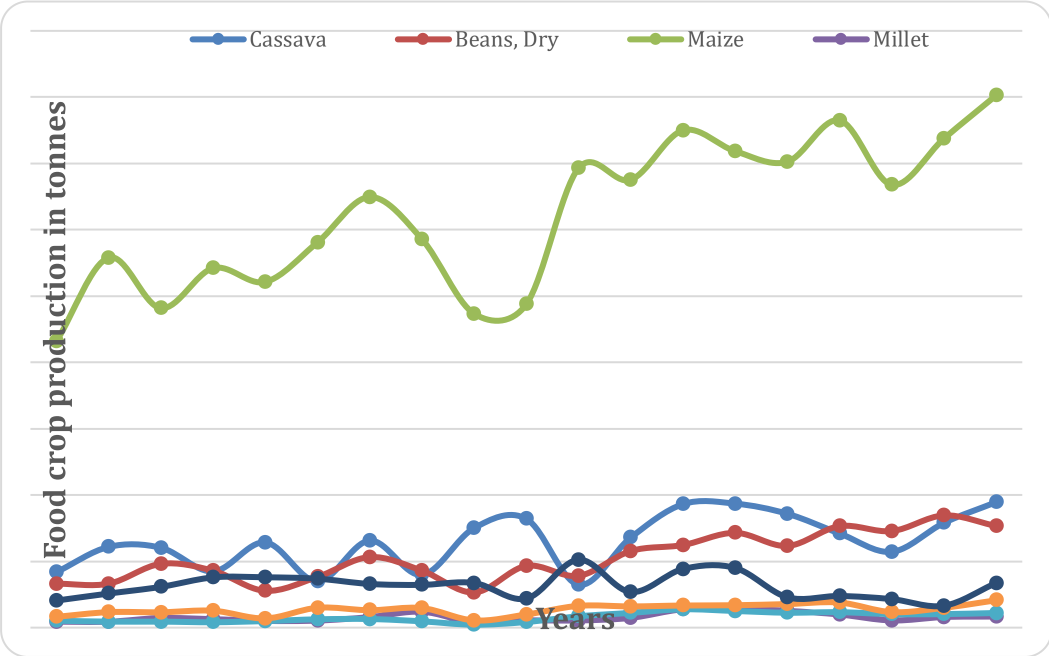


Figure 2.5. Different food crop production in tonnes, 2000-2018.

The food crop production has significantly increased in the period 2011-2018 compared to the 2000-2010 period where millet registered the greatest average increase in production of 114,641 tonnes from 50,594 tonnes, giving an increase of 126.6% while wheat production decreased by 10.9% (Table 2.2). During the same period, cassava, maize, dry beans, sorghum and rice paddy production increased by 79.60%; 62%; 47.3%; 46.0%; 33.2%, respectively.

Table 2.2. Average production in tonnes for the selected food crops.

Period	Food crop production in tonnes						
	Beans dry	Cassava	Rice paddy	Maize	Millet	Sorghum	Wheat
2000-10	544,748	392,259	272,9901	61,253	50,594	114,186	328,628
2011-18	802,665	704,507	363,731	99,111	114,641	166,827	293,008
Average % change	47.3	79.60	33.2	62	126.6	46.0	-10.9

Source: World statistics 2000-2018; Faostats 2000-2018

The cereal production (dry grain) for the period 2000-2017 (Figure 2.6) has shown an upward zig – zag trend with the lowest production recorded in the year 2000, 2003, 2005,2007 and 2010, which were attributed to years of droughts with exception of the year 2007/2008 that was a year of post election violence in the country displacing some of the farmers. Cereal production remained inconsistent in the 2000 to 2009 period with the greatest decline in yield reported in the year 2008 where cereal production was 2,866,111 million metric tonnes from 3,613,834 million metric tonnes in 2007, a decline that could be attributed to the 2007/2008 post election violence that displaced more than 300,000 families. The years 2010 to 2017 has registered an increase ending at 3.71 million metric tons in 2017. The greatest percentage increase of 49.97% in cereal production was reported in the year 2010 from the 2009 values of 2,898,884 million metric tonnes. The increase could be attributed to the Economic Stimulus Programme initiated by the Government of Kenya to jumpstart its economy after the 2007/2008 post election violence.

In addition, the government has initiated initiatives such as fertilizer subsidy that could have contributed to the increased cereal production. In 2018,production of potatoes, sorghum, and millet increased by 26.7%, 31.3%and 33.3%, respectively. The quantity of wheat sold more than doubled from 156.9 thousand tonnes in 2017 to 330.3 thousand tonnes in 2018. The total domestic sugar production increased by 30.6% from 376.1 thousand tonnes in 2017 to 491.1 thousand tonnes in 2018. On overall, marketed sugar production increased by 11.4% from KES 446.9 billion in 2017 to KES 497.9 billion in 2018 (KNBS,2018); Faostats, 2000-2018).

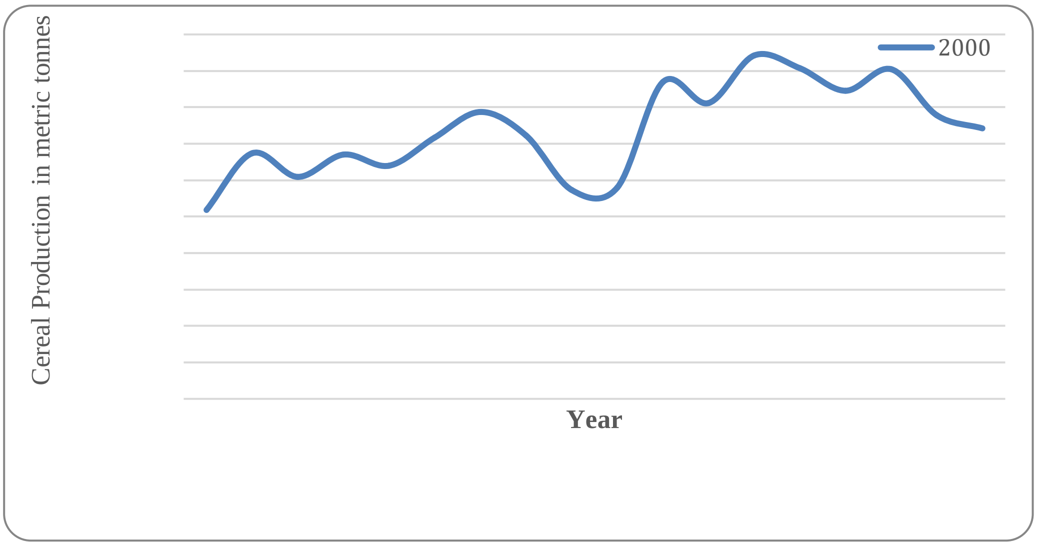


Figure 2.6. Cereal production in metric tonnes, 2000-2017.

(b) Industrial Crops. The industrial crops mainly include: tea, coffee, sugar cane, cotton, sunflower, pyrethrum, barley, tobacco, sisal and coconut, all of which contribute 55% of agricultural exports. The crops that have shown an upward trend in the past decade include: coconut at 46.9%, sugarcane, 27.7%; barley at 15%, sisal, 9.2% and sunflower seeds, 3.64% in a decreasing order. Crops whose production declined in the past decade include: pyrethrum, tobacco, cotton lint and coffee at 93.9%, 35.9%, 30.4% and 20.5%, respectively (Figure 2.7; Table 2.3). The value of coffee exports increased from KES 6.5 billion to KES 8.7 billion from 2000-2010 and 2010 to 2017 period respectively. Also coffee recorded 7.0% in growth and 9.2% increase in total sales to 36.8 thousand tonnes in the year 2018.

Pyrethrum recorded an average decline of 13% while the performance of sugar cane has been on decline. However, for the Pyrethrum, the sale has continued on a downward trend for the third consecutive year(from 2016, 2017 and 2018). Kenya produces about 400,000 tonnes of raw sugar annually while annual consumption is 600,000 tonnes, which necessitates importation from COMESA countries and else where to meet the demand. Other commercial crops whose production has remained low due to large unexploited potential are cotton, pyrethrum, oil crops, cashew nut, and sisal.

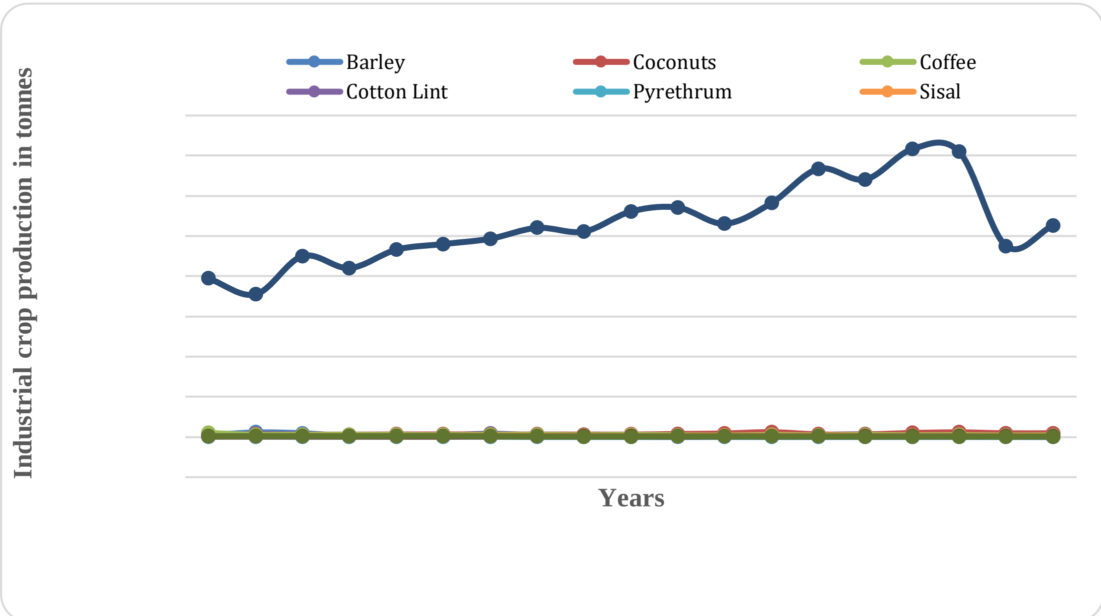


Figure 2.7. Industrial crops production in tonnes. Source: Faostats data (2000-2018).

Table 2.3. Trends in industrial crops production, 2000-2018.

Period	Barley	Coconut	Coffee	Cotton lint	Pyreth rum	Sisal	Sugar cane	Sunflow er seed	Tobacco
2000-10	577,010	62,525	53,913	6,405	5,299	2,2600	47,481	13,000	16,866
2011-18	66,357	91,881	42,837	4,455	323.9	24,682	60,101	13,473	10,812
Average (%) change	15.0	46.9	-20.5	-30.4	-93.9	9.2	27.7	3.64	-35.9

Source: Faostats data (2000-2018)

Tea production has contributed significantly to the Kenyan economy and it will continue to do so. Tea remains one of the leading foreign exchange earners in the country. Tea production increased from 287,100 tonnes in 2002 to 370,200 tonnes in 2007, while the value of exports increased from KES 34.3 billion to KES 47.3 billion Tea production in Kenya has generally shown an upward trend but with the lowest tea production year being 2000 at 236.2 million kgs. After which the value of tea increased to 328.5 million kgs in 2005 but with a decline in 2006, 2006, 2009, 2011, 2015 and 2017 (Figure 2.8), which were associated to periods of extreme weather events. The value of tea production increased by 12.1% t compared to 2017 and the quantity sold grew by 12.1% to 493.0 thousand tonnes in 2018

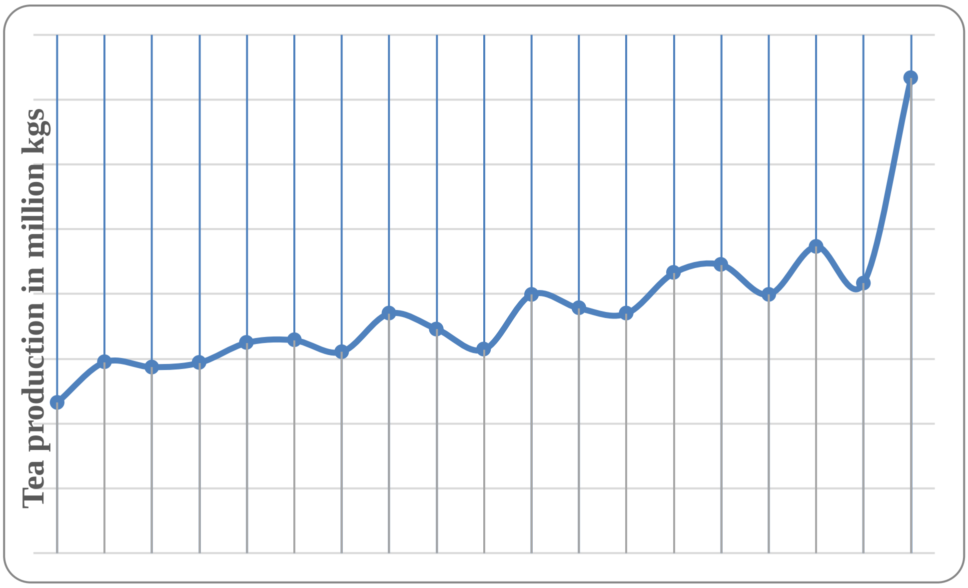


Figure 2.8. Trends in Tea production in millions kgs, 2000-2017.

Source: East African Tea Trade Association. https://www.eatta.com/80-tea/73-tea-market-reports-and-production-figures

(c) Horticulture*:* The horticulture crops include: cut flowers, vegetables, fruits, nuts, herbs and spices. While the value of total production increased from KES 84.1billion in 2014 to KES 153.7 billion in 2018 with cut-flowers, vegetables and fruits at 71% and7.4%, respectively (Table 2.4). The value of horticultural exports increased by 6.1% to 322.6 thousand tonnes in 2018.

Table 2.4. Trends in volume (tonnes) and values (KES billion) for the horticultural crops, 2014-2018

Year	Cut Flowers		Fruits		Vegetables		Total	
	Volume tonnes (000)	Value Kes billion	Volume tonnes (000)	Value Kes billion	Volume tonnes (000)	Value Kes billion	Volume tonnes (000)	Value Kes billion
2014	114.8	59.9	35.1	5.4	70.3	18.8	220.2	84.1
2015	122.8	62.9	46.2	6.6	69.7	20.9	238.7	90.4
2016	133.7	70.8	48.7	7.3	78.8	23.4	261.2	101.5
2017	160.0	82.2	56.9	9.0	87.2	24.1	304.1	115.3
2018	161.2	113.2	75.6	12.8	85.8	27.7	322.6	153.7

Source: KNBS (2018)

Food and non-food production index in Kenya

The food production index (PIN) covers food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because, although edible, they have no nutritive value. Practically all products are covered, with the main exception of fodder crops. Non-food production index covers non-food items. The food production index was lower than the non-food production index during the 2002-2004 period but showed a more upward trend to the year 2016 while the non-food production declined in the years 2006, 2009, /2011, 2012 and 2015 **(**Figure 2.9).

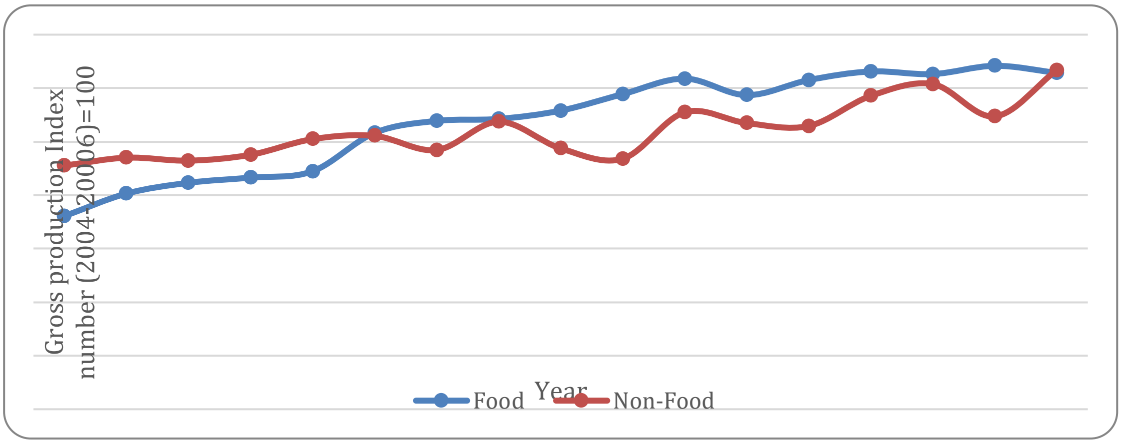


Figure 2.9. Food and non-food Gross production Index (2004-2006).

Source: Faostats (2000-2016); KNBS, 2008-2016

The PIN increased from 73.1 in the year 2000 to 125.8 in 2016 (Figure 2.10). Between 2000 and 2016, PIN grew substantially from 73.1 to 125.8 index growing at an average annual rate of 3.1% (Faostats, 2000-2016). The year 2005 recorded the highest increase of 16.26% while the highest decrease of -2.08% was recorded in 2016. Other years that recorded a decline in food production index were 2011, 2013 and 2016 and this was associated with poor weather conditions in the country (World Bank Data and Faostats, 2016).

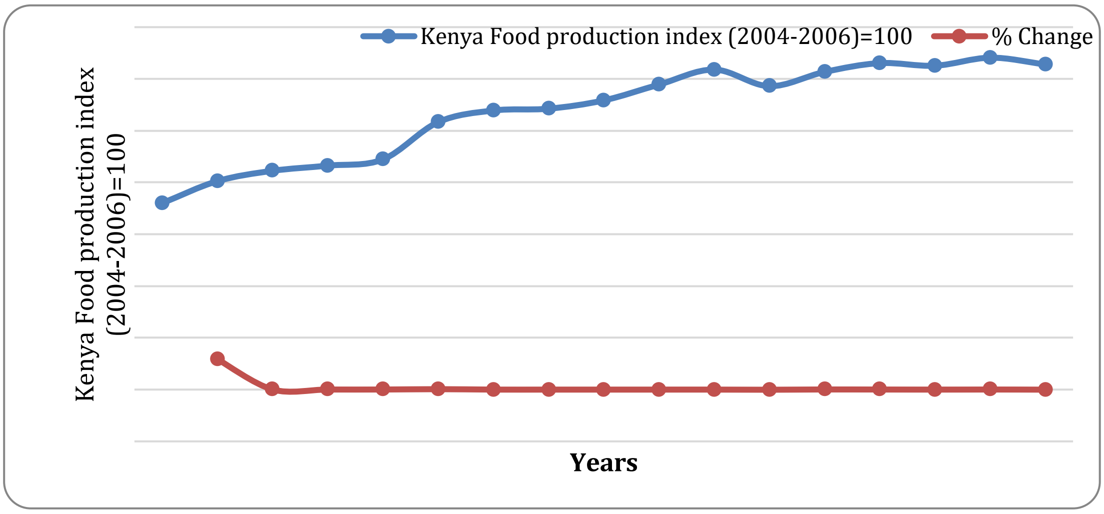


Figure 2.10. Kenya Food production index (2004-2006) = 100, 2000-2016.

On the other hand, the agricultural total factor (TFP) growth has been low and erratic over the past decade. The last growth rate has been below 5% with negative growth rate recorded in 2003, 2007 and 2011 (Figure 2.11).

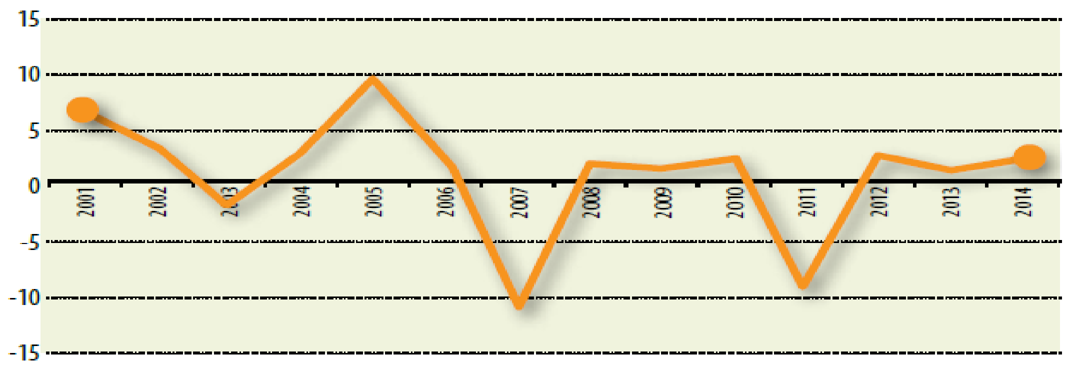


Figure 2.11: Total factor production, 2001-2014.

Source: Fuglie (2012); Fuglie (2015); KBA (2018)

On use of fertilizer use, a Kenyan farmer is reported to be using an average of 32Kg of fertilizer applied per hectare in Africa. This however falls short of the international recommended standards of 50kg per hectare. The fertilizer usein the country increased from 27.2 kg/ha in 2002 to 43.6 kg/ha in 2011 (Figure 2.12), which was the highest value reported but continued to show a fluctuating trend with lowest level reported in 2015 with a rise to 38.2kg/ha in 2016.

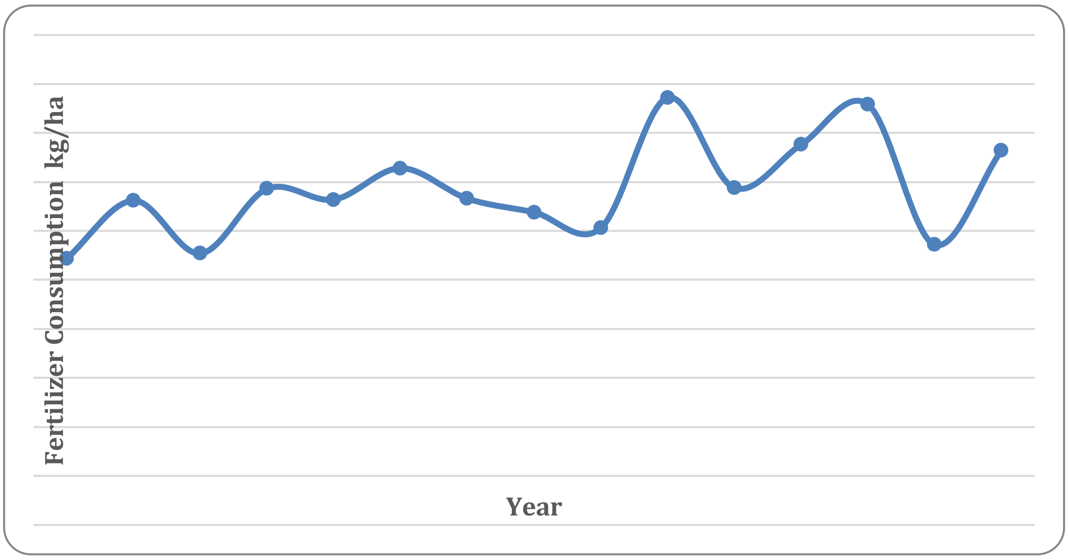


Figure 2.12. Fertilizer consumption in Kenya in kg/ha of the arable land, 2002-2016.

Source: IFDC, 2012.

There has been remarkable increase in the use of pesticides for purposes of controlling and managing crop pests. For example, in 2005, approximately 7,047 metric tons of pesticides, valued at US$54 million were imported **(**Macharia *et al,* 2009; PCPB, 2005). The pesticide import values have continued to increase from

2000 to 2013, and started to decline in 2014 to 2017 (Figure 2.13). Kenya is the leading producer of a natural pesticide, pyrethrin, which is a broad-spectrum insecticide made from dried flowers of pyrethrum (Chrysanthemum cinerariaefolium). However, about 95% of the crude pyrethrin is exported for processing with the final product earns a premium price.

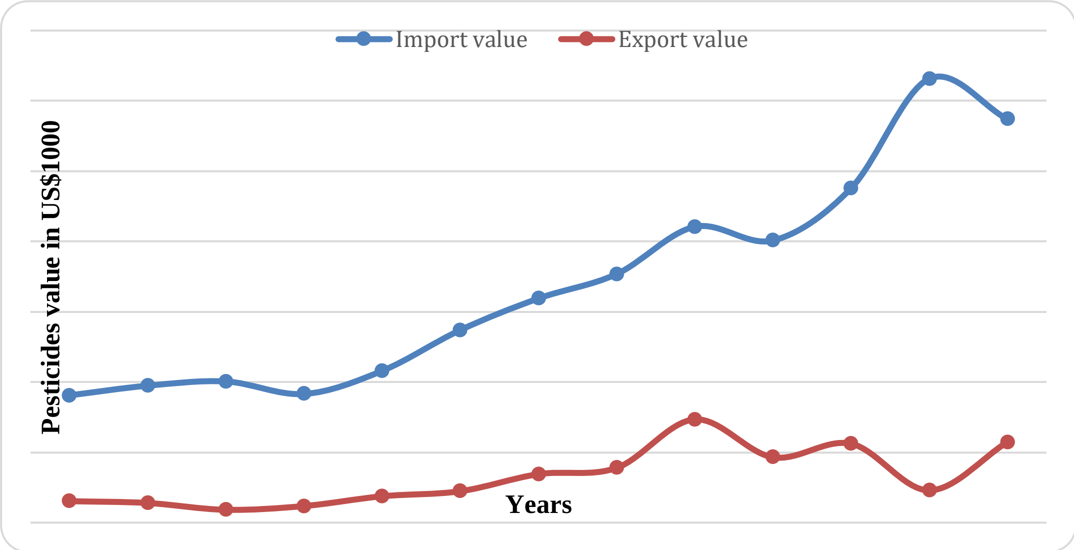


Figure 2.13. Pesticide values of import and export in Kenya, 2000-2017.

Livestock sub-sector

The livestock subsector has important role in the overall economy and livelihoods of a large proportion of rural population. The contribution of the subsector is about 12% of the country's GDP and 42% of agricultural GDP (SNV, 2008). Majority of the livestock is in arid and semi arid lands which account for more than 80% of Kenya's landmass. The ratio of livestock numbers in pastoral areas estimated as per IGAD 2017 methodology as cattle 44%, sheep 57%, goats 50% and camels at 100% (Nyariki and Amwata, 2017). Since 2000, livestock numbers have been on the increase (Figure 2.14) but with a decline in livestock numbers in 2006, which was associated with the 2004/ 2005 drought. The key livestock subsectors are beef, dairy, sheep, goats, camel, poultry, piggery and emerging livestock. The value of marketed livestock and livestock products increased by 8.3% to KES 146.8 billion in 2018 from 2017 (KNBS, 2018). Livestock can be categorized into ruminants and non-ruminants as detailed below.

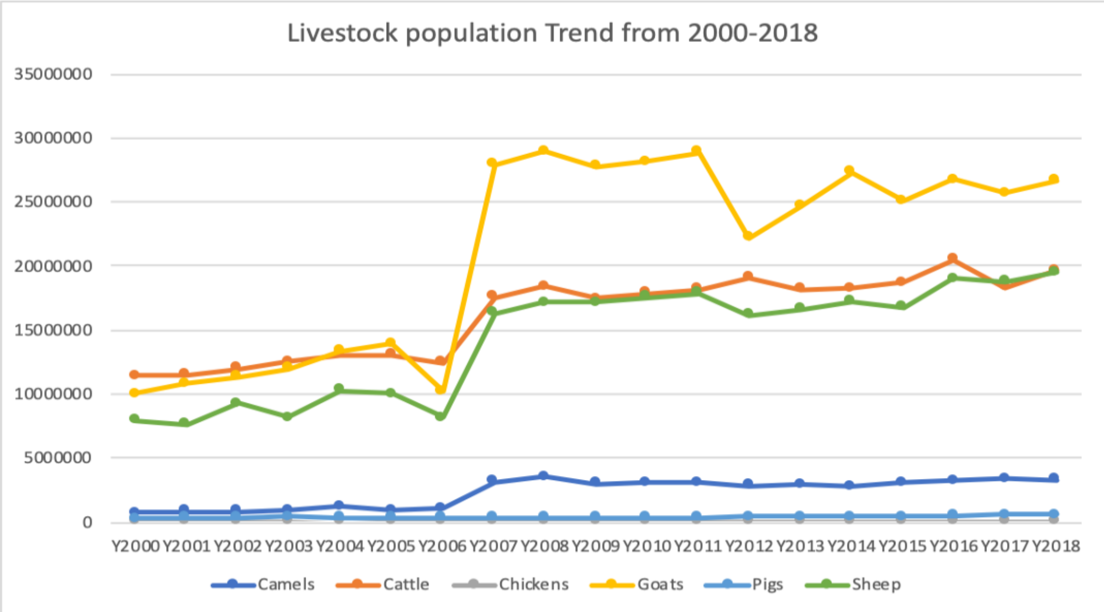


Figure 2.14. Livestock population trends, 2000-2018. Source: Faostats data (2000-2018).

Ruminants

The ruminants that are reared mainly include cattle, sheep and goats and camels. The ruminant numbers have shown an upward trend for the past two decades except with an exception of year 2006, where all species experiences a decline in population as shown in Figure 2.15 and Table 2.5. The camels, sheep, goats and cattle have increased at 76%, 32,1%, 46.6% and 50.4%, respectively (Figure 2.15 and Table 2.5).

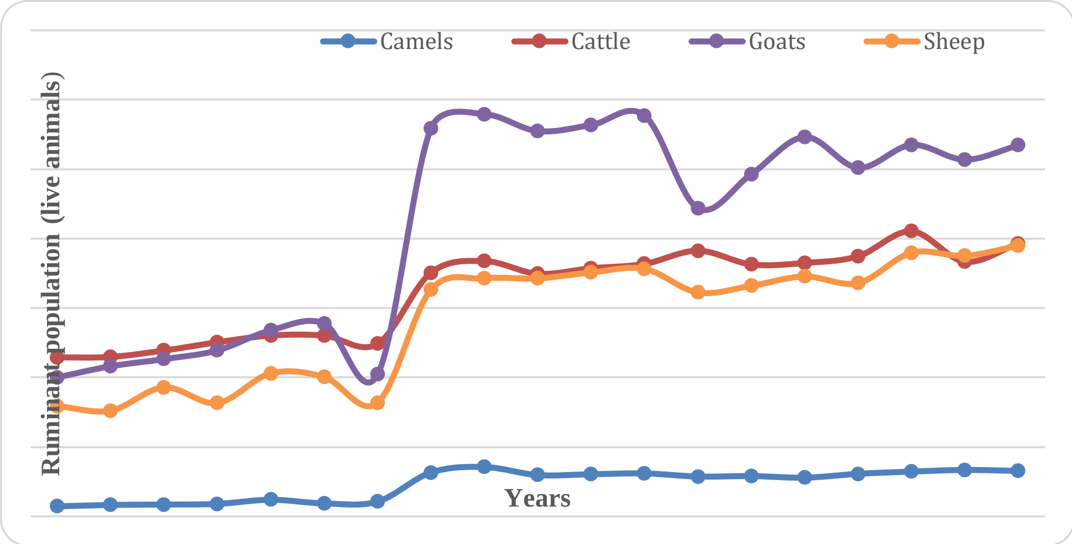


Figure 2.15. Trends in ruminant population, 2000-2018.

Source: Faostats 2000-2017; KNBS, 20010-2018.

Table 2.5. Average ruminant population for the period 2000 to 2018.

Period	Camels	Cattle	Goats	Sheep
2000-2010	1742877.09	14281894.2	17668235.3	11785382.7
2011-2018	3066674.75	18865081.3	25904429.1	17729670.5
Average(%) change	76.0	32.1	46.6	50.4

Source: Faostats 2000-2017; KNBS, 20010-2018

The country's dairy cattle are estimated at 3.5 million head. Dairy cattle are mainly kept in medium to high-rainfall areas. The key dairy breeds kept include Ayrshire, Friesian, Guernsey, Jersey and cross-breeds. The annual milk production increased from 2.224 billion litres in 2000 to 3.749 billion litres in 2018, giving an average increase of 3.6% annually. For the period 2000 - 2010, the average milk production was 3.18 billion litres, which increased by 15.64% to 3.68 billion litres in 2011-2018 period (Figure 2.16 and Table 2.6).

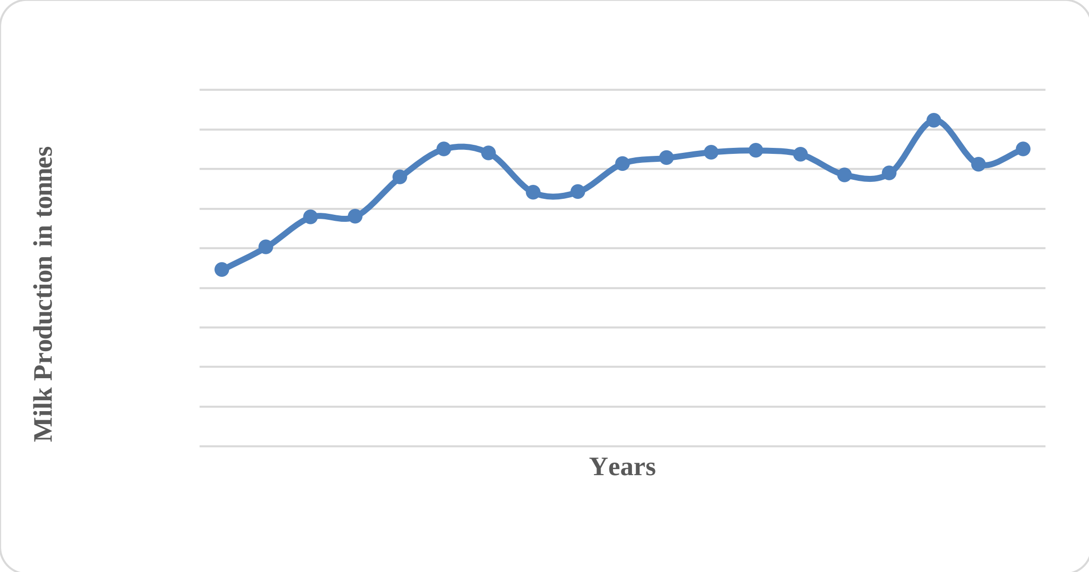


Figure 2.16. National milk production in tonnes for the period 2000-2018.

Source: Faostats 2000-2017; KNBS, 20010-2018

Table 2.6. Average national milk production in tonnes for the period 2000-2010 and 2011- 2018

Period	Average milk production (tonnes)
2000-2010	3,180,688.09
2011-2018	3,677,990.38
Average % change	15.64

Source: Faostats 2000-2017; KNBS, 20010-2018

Beef cattle population in the country is estimated at 9 million with the main beef species being East African Zebu, Boran, Sahiwal and cross-breeds. On average, the country produces 320,000 tonnes of beef annually worth KES 62.1 billion. The annual trend in beef production from 2000 to 2018 is shown in Figure 2.17. The average cattle meat production for the period 2000-2010 was 384,042 tonnes which increased to 499,164 tonnes in the period 2011 to 2018, giving a 30% increase in cattle meat produced. Also, the country has an estimated 13 million goats and 10 million sheep. Annual meat production is estimated at 84,000 tonnes of mutton and chevon worth KES 14 billion. Camel is also an important ruminant mainly kept in the northern Kenya due to his ability to withstand very harsh climate. The camel produces milk, meat, income and serves as pack animals. Currently, 900,000 camels are producing 7000 tonnes of meat worth KES 1 billion, and 200 million litres of milk worth KES 2 billion annually.

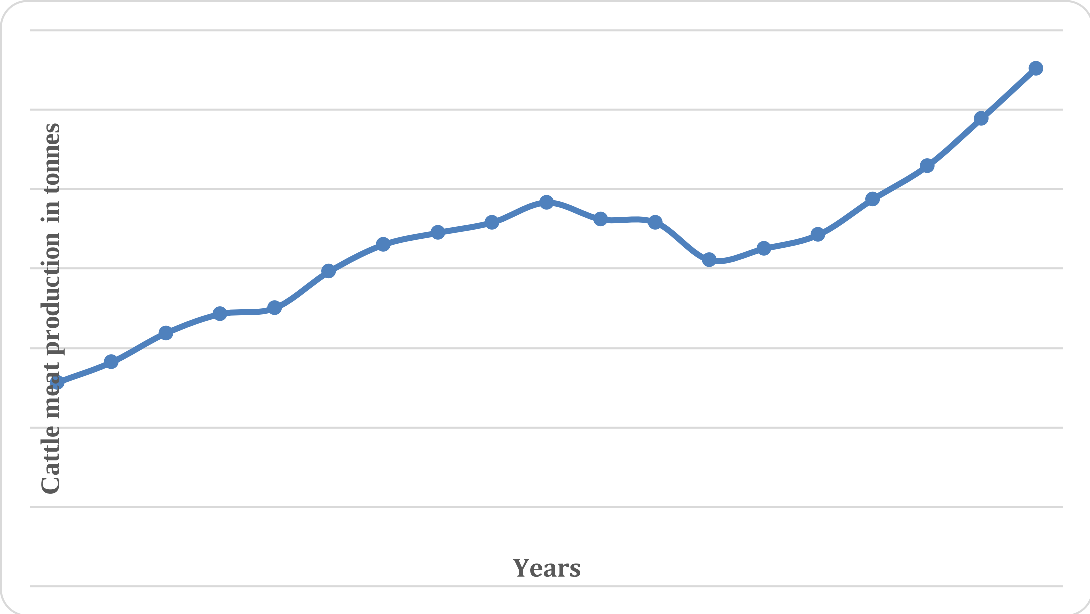


Figure 2.17. Cattle meat production in tonnes from 2000-2018.

Source: Faostats 2000-2017; KNBS, 20010-2018

Non-ruminants

The non-ruminants include poultry, rabbits and hares and pigs (Figure 2.18 and Table 2.7). The 2000-2010 period to 2011-2018, the non-ruminant average population has increased by 77%, 43.9% and 35.4% for pigs, chicken and rabbits and hares respectively (Table 2.7).The population trend of the rabbits and hares have stagnated all the years probably due to the limited knowledge of it as an emerging production system. The population for chicken has been on the increase for the past decade. The increase could be attributed to chicken being used to diversify incomes as they are not climate dependent.

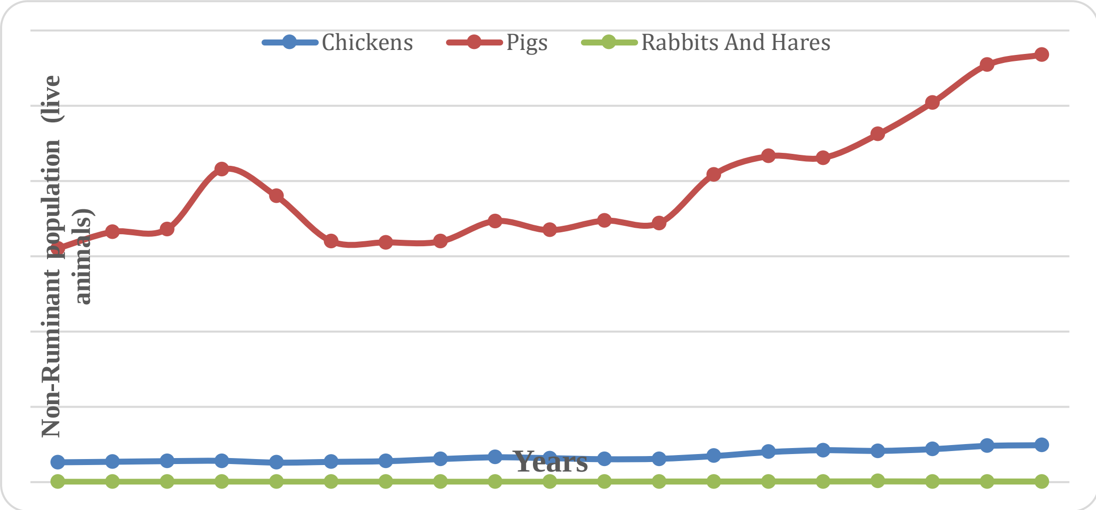


Figure 2.18. Non-ruminant livestock production for the period 2000-2018.

Source: Faostats 2002 -2018

Table 2.7. The non-ruminant average population trends for the 2000-2010 and 2011 - 2018 periods.

Periods	Chicken	Rabbits and hares	Pigs
2000-2010	28713.55	341950.55	472.73
2011-2018	41286.88	463156.63	836.63
Average increase (%)	43.90	35.40	77.00

Source: Faostats 2000-2017; KNBS, 20010-2018

For the period 2000 to 2018, livestock PIN and Crop PIN grew at 3.04 and 3.1 respectively (Figure 2.19). Crop production Index number had higher values than livestock production Index numbers over the years with exception of the year 2004, 2008, 2009 and 2011 when livestock PIN was higher than crops.

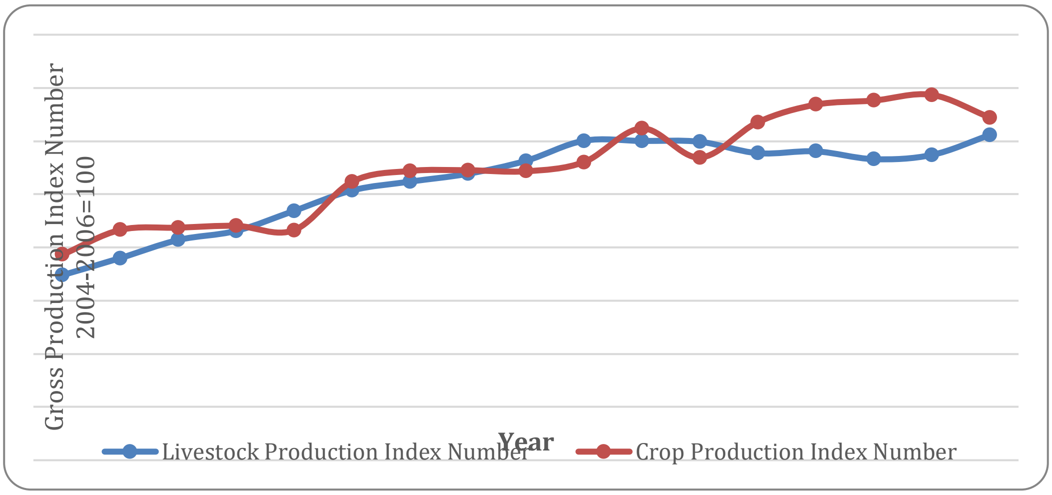


Figure 2.19. Crops and livestock production index; Source: Faostats data, 2000 - 2018)

Honey and wax production

Apiculture also known as bee production is an important economic activity in Kenya. The country produces an estimated 100,000 metric tonnes of honey and 140 tonnes of beeswax annually, all valued at KES 4.3 billion (Kiptarus and Asiko, 2014; Nyariki, 2019). Due to the low investment and variable costs involved, beekeeping is becoming increasingly popular in rural areas especially pastoral and agropastoral areas. According to the National Farmers Information Service (NAFIS), 80% of honey comes from pastoral areas and specifically from the ASAL traditional log hives.[1]

Table 2.8. Bees wax gross production value (current million US$).

Year	2010	2011	2012	2013	2014	2015*	Average
Gross production Value (million KES)	700	668	650	1,460	2,270	1,900	1,280

* 2015 Figures are author estimates; $1 is Kshs 100; Source: Faostat (2014)

[1]www.nafis.go.ke/livestock/beekeeping/.

Challenges facing livestock production

Several reports and documents such as ASTGS (2018); WFP/ ATLAS (2016), ASDS (2010); have highlighted the challenges that hinder sustainable livestock production to include:

- *Weak implementation and reinforcement of policies and strategies.* The strategies and policies on livestock on paper is well written and articulated but the implementation on the ground is minimal. This is attributed to lack of adequate technical and financial resources to adequately implement the proposed actions on the policy documents.
- *Climatic hazards:* rainfall and temperature changes influence livestock production. Pastoral areas receive low and unreliable rainfall and at times prolonged drought lead to lack of water and sufficient pasture for the animals resulting in massive deaths. In other times the rainfall occurs in erratic and torrential nature, leading to flash floods leading to livestock deaths and erosion of livelihood bases of the livestock dependent households.
- *Pests and diseases:* tick and tsetse fly borne diseases e.g. rinderpest, anthrax, east coast fever are common in the pastoral areas and contribute to deaths of large herds of animals.
- *Overstocking:* often pastoralists keep large herds far exceeding the land carrying capacity. This leads to overgrazing, soil erosion and land degradation.
- *Poor pastures:* most pastoral areas have poor soil that cannot support quality pastures. Most areas are thus covered by poor pastures consisting of tuft grasses (low in nutritive value) and bare land.
- *Cattle rustling*: a major cause of insecurity and leads to loss of life, livestock and destruction of property.
- *Poor road and transport network*: makes the main livestock production areas inaccessible such that households cannot get their animals to the market to earn an income.
- *Inadequate veterinary services* making it difficult to treat or improve the animals. This results from insecurity and the migratory nature of pastoral herders making it difficult to provide services at defined locations.

- *Lack of adequate data and information:* Kenya conducted the first livestock census in 2009. Before 2009, livestock population was based on estimates but the 2009 census included a component on livestock population which allowed for more accurate estimation but remains a one point data.

Fisheries and aquaculture sub-sector

Fisheries resources and national economy

The fishery resources play a critical role in household food and nutrition security and as a source of livelihood, incomes and employment creation. The subsector contributes about 0.5% of the national GDP annually. The two main sources of fish are fresh water and the ocean, with fresh water accounting for the dominant 85% of the national fish production. The total fresh water fish production has been on the decline since 2014, while fish production from marine has experienced modest decline. Total fish output in 2018 was 148.3 thousand tonnes with a total value of KES 24.0 billion (Table 2.9).

Table 2.9. Trends in national fish production in tones and value (KES), 2014-2018.

Types of fish	2014	2015	2016	2017	2018
Freshwater (Tonnes)	159,340	141,698	123,513	111,814	124,127
Marine (Tonnes)	23,286	22,126	24,165	23,286	24,220
Total (tonnes)	182,626	163,824	147,678	135,100	148,347
Value (Kes Millions)	25,582	24,546	24,426	22,957	23,984

Source: KNBS (2018).

Fish species and their production trends

The most common fishes in Kenya are shown in Figure 2.20. Freshwater and diadromous fish forms the bulk of the fish compared to other fish species. The majority of fish species are on the decline (marine Fish NEI (29%), crustaceans (4%) and freshwater and diadromous fish at 0.2%). The fish species that have shown increase in numbers include: cephalopods (228%); demersal marine fish (121%), aquatic animals NEI (73%), pelagic marine fish (67%) and molluscs excl. cephalopods (57%) (Table 2.10).

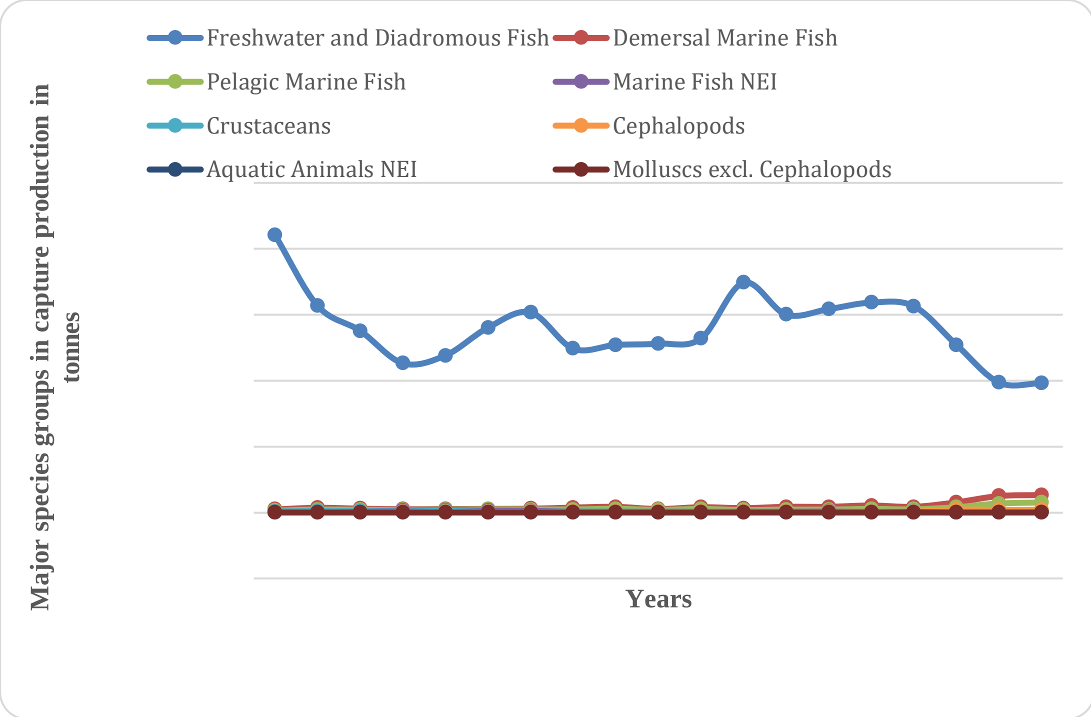


Figure 2.20. Population trend of the of different fish species, 2000-2018.

Source: Faostats (2000 – 2018)

Table 2.10. Average numbers of different species over the 2000-2010 and 2011-2018 period.

Period	Freshwater & diadromous Fish	Demersal marine fish	Pelagic marine fish	Marine fish NEI	Crusta-ceans	Cepha-lopods	Aquatic animals NEI	Molluscs excl. Cephalopods
2000-10	140,032	3,110	2225	927	719	353	26	15.6
2011-18	139,763	6,869	3,722	660	691	1,160	44.9	24
Average % change	-0.2	121	67	-29	-4	228	73	57

Source: Faostats (2000 – 2018)

Fish production in the inland waters has been on the decline for the past decade - from 210,343 tonnes in 2000 to 98,000 tonnes in 2018 (Figure 2.21) - a decline of 53% over the period or an average annual decline of 2.81%. However, fish production in the marine water has been rising gradually. Comparing the two periods 2000 – 2010 and 2011-2018, inland fish production showed a decline of 0.19% while the marine fish production increased by 78.8% over the same period (Table 2.11).

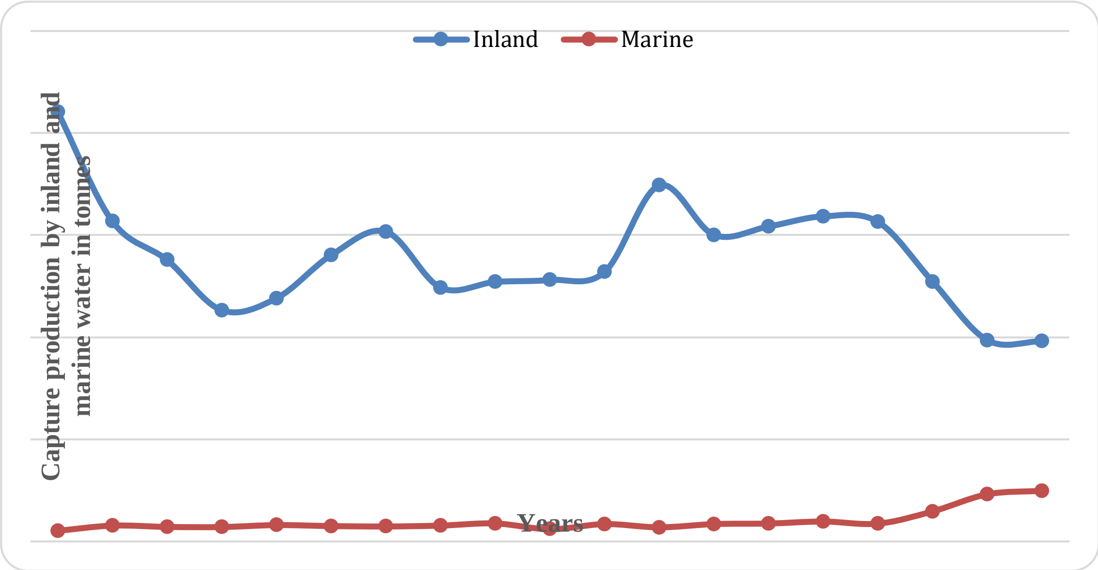


Figure 2.21. Capture production (in tonnes) by inland and marine water.

Source: Faostats 2000-2017; KNBS, 20010-2018

Table 2.11. Average and average increase for the period.

Period	Inland	Marine
2000-2010	140,049	7358.45455
2011-2018	139780	13154.125
Average % change	-0.19	78.8

Source: Faostats 2000-2017; KNBS, 2010 - 2018

For the past decade, the value of fish products for export have been on the decline. The Nile perch is the most commercially important species in the export trade, contributing about 90% in both volume and monetary value of Kenya's total fish exports. Exportable Nile perch products include the fillet, fish maws, and the gutted, headless whole fish. Marine fish products such as crustaceans (prawns, lobsters and crabs), molluscs (octopus and squid), marine fish, freshwater crayfish, and small quantities of live ornamental fish are also exported. In contrast, the fish imports have increased by 25.5% annually and by 238% the 2010 values (Figure 2.22).The value of fish export for the period 2000 - 2010 was averagely US$ 57,112,000 compared to US$ 39,638,000 in 2011 - 2018 period, thus a decline of 30.6%.

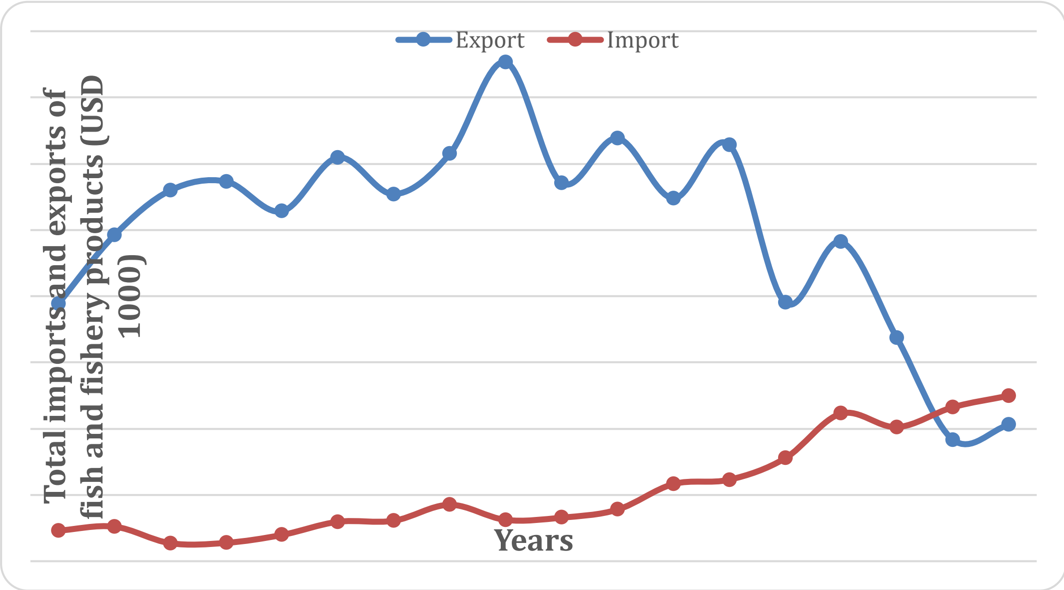


Figure 2.22. Total imports and exports of fish and fishery products (USD 1000).

Source: Faostats (2000 – 2018)

Aquaculture and culture fish production in tonnes

The production of fish through aquaculture has been increasing from the 512 tonnes in 2000 to 1,524 tonnes in 2018, while the capture fish production has been declining over time from 164,500 tonnes to 122,805 tonnes in 2018 (Figure 2.23). A comparison of fish production levels for the two periods 2000 - 2010 and 2011 - 2018, capture fish production has increased by 3.7% while aquaculture production has increased by 551% (Table 2.12). This shows that the government efforts of increasing fish production through aquaculture is bearing fruit.

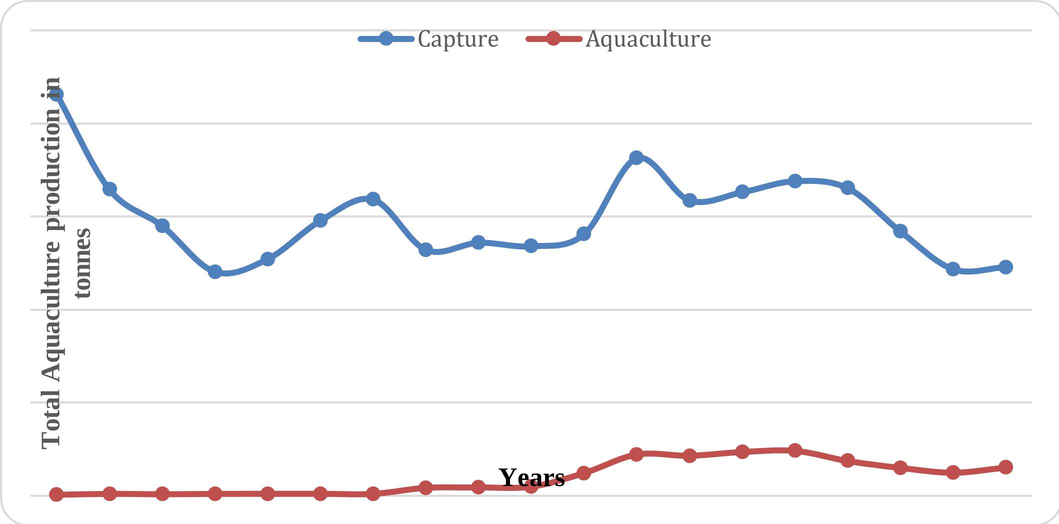


Figure 2.23. Aquaculture and culture production from 2000-2018.

Source: Faostats 2000-2017; KNBS, 2010-2018

Table 2.12 Average aquaculture and culture production for the period 2000-2010 and 2011 to 2018

Period	Capture	Aquaculture
2000-2010	147,408	2,924.18
2011-2018	152,934	19,040.13
Average % change	3.7	551

Source: Faostats 2000-2017; KNBS, 2018

Cage fish farming is an emerging or new fish production type. That entails a netted enclosure being suspended in an aquatic environment – like a sea or lake. Cage farming is mainly practiced in Lake Victoria – currently produce about 40,000 tons of fish per year. Catching wildfish, with nets or lines, and cage farming are the only two ways fish is harvested from the lake. The merits of cage fish farming include: high production of fish per unit volume of water; less investment needed per unit of production compared to pond or land culture; use of existing water bodies reduces water demands on land and also less affected by drought; and ease of relocation of cages from one site to another. However, with the high density of fish used in cage fish farming, diseases and parasites can spread quickly among the fish.

Landscape and agroforestry

Landscape

The agricultural landscapes, agro-ecological distribution and crops grown in Kenya are shown in Table 2.13a and 2.13b). The farming systems in the country are primarily rain-fed and small-scale, where farmers own land averaging between 0.3 to 3 hectares in size (RoK, 2010), contributing about 75% of total agricultural output produced on rainfed agricultural lands (RoK, 2012a). These farming systems can be categorized as 1) small scale integrated crop-livestock/fish-tree farming systems; 2) crop-tree systems; 3) crop-livestock tree systems; 4) rice-fish integrated systems and 5) fish poultry systems. Livestock is kept under smallholder zero-grazing systems, an intensive livestock production system involving the “cut and-carry” method of feed management. This system is characterized by ownership of one to two dairy livestock units and is found in many parts of medium to high agro-ecological potential areas and by the growing of coffee, tea and/or potato (Osumba and Rioux, 2014). The smallholder mixed crop-livestock system, with maize-based dairy production with or without cash crops, extends across 30% to 35% of the country’s land area and is characterized by drought- tolerant and fast maturing livestock (beef, small ruminants) and crops (pigeon peas, cowpeas, *dolicos,* sorghum, millet, cassava and sweet potatoes).

The large-scale mixed crop-livestock-tree farming system, which covers over 80% of the country’s land area, takes two forms, the first being private or government owned ranches that are commercially well-equipped and use modern technology. Improved dairy herds grazed on improved pastures are common in this system in Kenya, with fodder conservation and supplementary feeds used to varying degrees. Pasture-legume mixtures, hay and purchased feed are commonly used as well. The second form includes extensive livestock production systems where crops are grown along the river valleys and livestock herd sizes are large due to communal grazing systems, and there is low use of purchased inputs like feed, drugs and artificial insemination (ASAL, 2012).

Table 2.13a. The agricultural landscapes in Kenya.

Landscapes/ farming systems	Description and agro-ecological zones	Geographical location
Highland perennial farming system	Involves growing of crops and raising of livestock in small pieces of land for maximum yield per unit area, through use of high levels of labour and capital by application of modern farming technologies. The crops grown include maize/ coffee/ tea/ pyrethrum, livestock and trees	Central, Kisii, western, eastern and Uasin Gishu and Kericho Counties
Maize mixed farming system	Maize, beans, cowpeas, pigeon peas cotton, sunflower, soybean, groundnuts, livestock (dairy)	Central, Coast and semi-arid areas
Root crop farming system	Mostly in the most humid and sub-humid agro-ecological zones Maize/ sorghum, trees	Eastern Kenya, Western and coast regions of Kenya
Intensive farming system/ mono-cropping	Involves the commercial production of large quantities of crops and livestock on large farm	Eastern Kenya, Kericho, central
Large commercial farming system	Farming system which involves growing of crops and rearing of animals on large piece of land applying modern farming technologies.	Kiambu, Narok, Laikipia, Kericho, Taita-Taveta
Irrigated farming system	It cover sub-humid to semi-arid zones. In majority of the cases, irrigated cropping is often complemented by rain-fed or animal husbandry. Control of water may either be full or partial.	Eastern and coastal areas in Kenya
Rice-tree crop farming system	Humid and sub-humid agro-ecological zones) coffee and banana is completely complemented by rice, cassava, maize, and legumes and low cattle numbers	Eastern Kenya, Western regions of Kenya
Pastoral farming system or eextensive system:	Extensive system:- located in the arid and semi-arid zones; Examples of this include: raising sheep for wool, dairy farming, and raising beef cattle	Northern Kenya, Southern Kenya and parts of coastal Kenya

Source: Modified from CIAT/WB, 2015)

Table2.13b. Agro-ecological zones and the crops grown in f Kenya.

Agro-climatic zone	Moisture index (%)	Annual rainfall (mm)	Land area (%)	Crops Grown/ Livestock kept
Agro-Alpine (humid)	>80	1,100-2,700	12	This zone includes mountains has no agriculture but a source of rain and some rivers/streams.
High potential (sub-humid)	65-80	1000 – 1,600	12	Coffee, Maize, peas, citrus, forestry, Dairy production
Medium potential (semi-humid)	50-65	800 – 1,400	12	Coffee, maize, beans, pigeon peas, sunflower, sorghum, fruits,

Transitional (semi-humid to semi-arid)	40-50	600 – 1,100	5	Maize, beans, pigeon peas, cotton, sunflower, sorghum, fruits, forests, cattle, sheep and donkeys
Semi-arid	25-40	450 - 900	15	Maize, beans, pigeon peas, finger millet, tobacco, cattle, sheep, goats
Arid	5-25	300-550	22	Finger millet, sorghum, cassava
Very arid	<15	150-350	46	Camels and Goats

Source: Sombroek, et al., 1982; Jaetzold and Schimdt, 1982

The land-use changes have taken place in the past two decades (Table 2.14). The increase in area coverage on forest land could be attributed to increased government efforts to promote agroforestry and increase forest cover to 10% by 2030.Wetlands and grasslands have shown a decline since 2000 to 2015 (Table 2.15).

Table 2.14. Land -use area changes in Kenya in 000 ha (2000-2015).

Land use	2000	2005	2010	2015
Forest land	3,557	4,047	4,230	4,413
Crop land	9,661	9,868	10,072	10,276
Grassland	41,654	41,496	41,080	40,664
Settlement	87	109	126	143
Other lands	1,574	1,035	1,044	1,053
Wetland	1,504	1,482	1,485	1,488
Total area	58,037	58,037	58,037	58,037

Source: Modified from FAO (2015); ROK (2019)/Forest

Table 2.15. National land-use changes in 000ha from 2000 to2015.

Type of land use	2000	2005	2010	2015
Forest land (000 ha)	6.13	6.97	7.29	7.60
Crop land (000 ha)	16.65	17.00	17.35	17.71
Grassland (000 ha)	71.77	71.50	70.78	70.07
Settlement (000 ha)	0.15	0.19	0.22	0.25
Other lands(000 ha)	2.71	1.78	1.80	1.81
Wetland (000 ha)	2.59	2.55	2.56	2.56
Total area (000 ha)	100.00	100.00		

Forests and related forestry activities contribute to improved agricultural productivity through conserving soil and water and enhancing soil fertility. The percent forest cover has been increasing from 2000 at 3,557 000ha to 4,413, 000 ha 2017 as shown in Table 2.16 and Figure 2.24).

Table 2.16. Trends in forest cover in thousands of hectares, 2014-2018.

Types of Forests	2000	2005	2010	2014	2015	2016	2017	2018
Natural Forests (000 Ha)	3,397*	3,865*	4,040*	3,907	3,969	3,994	4,033	4,033
Plantations(Ha)	160*	182*	190*	197	217	191	189	191
Total (Ha)	3,557	4,047	4,230	4,103	4,158	4,185	4,222	4,224
Forest %age	6.25	6.97	7.02	7.1	7.16	7.21	7.28	7.28

Source: KNBS 2018

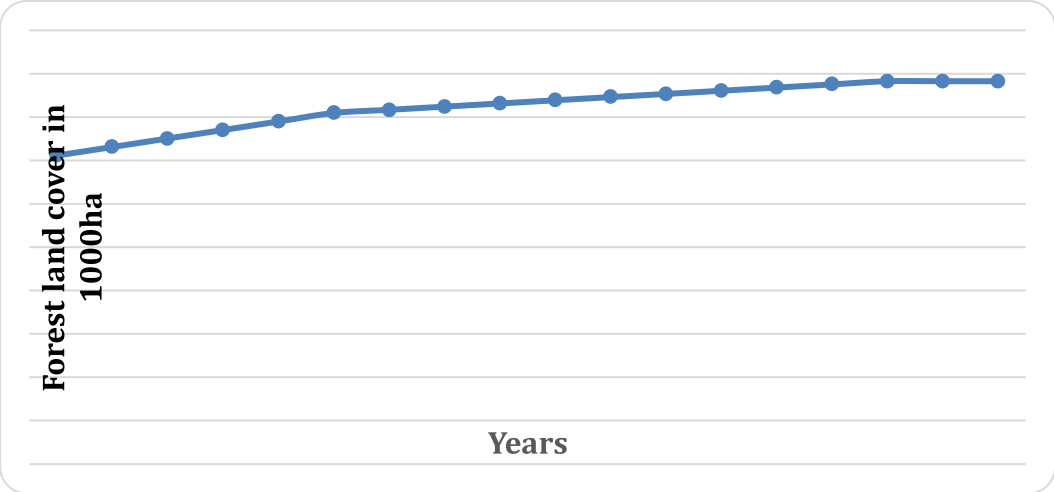


Figure 2.24. The trend in national forest cover.

Source: Faostats, 2000-2017

Agroforestry

Agroforestry has been widely promoted on the basis of its benefits to improve the livelihoods of smallholding farmers, rehabilitate degraded landscapes, and enhance the services provided by nature. Agroforestry plays an important role in strengthening resilience to climate change by enhancing a range of products such as human food, fiber, fodder, timber, poles, medicine, and firewood. It also provides services which include soil fertility, shade and serves as windbreaks. Agroforestry is a traditional practice that has been adopted by farmers for many years. Some of the major agroforestry systems in Kenya include agrosilvicultural, silvipastoral and agrosilviculture, within which other agroforestry practices are widely undertaken. Agroforestry, if integrated at the household level, has the potential to provide economic, social and environmental benefits that are capable of addressing household income, fuel, food supply and environment related challenges. Adoption of agroforestry technology depends on the following criteria: food (supplying immediate household needs), income (providing cash to service other needs), future (providing savings for longer-term needs, such as education for children), building (providing wood materials for construction of new house for instance), and erosion control (activities that minimize soil loss).

Productive resources

The productive resources fundamental for agriculture includes, Land, soils and water as described below.

Land resources

Land is not only the most important factor of production but also a very emotive issue in Kenya. Tenure security and equitable access to land other natural resources are central to rural poverty reduction in Kenya (Gichenje *et al.,* 2019). Demand on land for agricultural development and pressures from a rapidly growing population have led to unprecedented land use changes. As a result, unsustainable land use is causing land degradation. Land degradation (both chemical and physical) manifests itself in many forms such as soil erosion, loss of soil fertility, salinity, reduced vegetation cover, reduced biodiversity and ecosystem services and degradation are closely linked to poverty and food insecurity. degradation are closely linked to poverty and food insecurity (KCSAS, 2017). The national trends in land-use show an upward trend from 2000 to 2017 (Figure 2.25) (Amwata *et al*, 2015).

The agricultural land has increased from 26.7 million ha in 2000 to 27.6 million ha in 2010, giving an increase of 3.6%; for the arable land and land under crops increased by 18.6% and 10.4% respectively. The classification of land potential to agricultural production is based primarily on rainfall. The agro-ecological zones in Kenya are described in Table 2.16 below. High potential land falls within an area characterized by mean annual rainfall of at least 857.5 mm, while medium and low potential lands receive mean annual rainfall of 735 – 857.5 mm and 612 mm or more, respectively. About 33% of the 52 million ha (17 million ha) are endowed with some rainfall to support crop production (Jaetzold and Schimdt, 1982). The distribution of arable land and drylands in relation to their crop production potential in Kenya is illustrated in Figure 2.26.

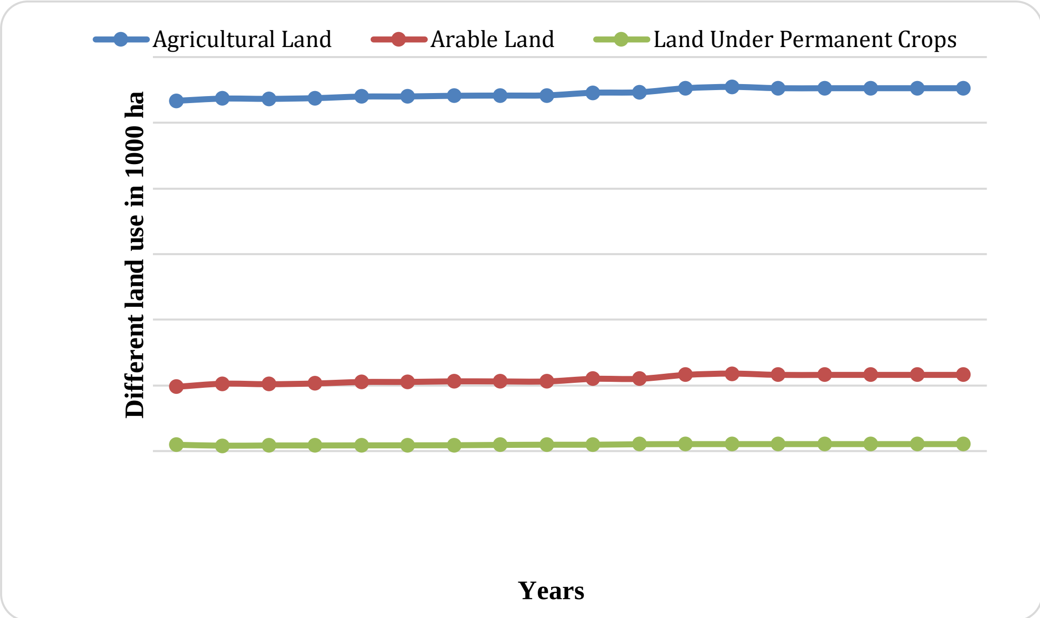


Figure 2.25. National trends in Agriculture, permanent crops and arable land starting 2000-2017.

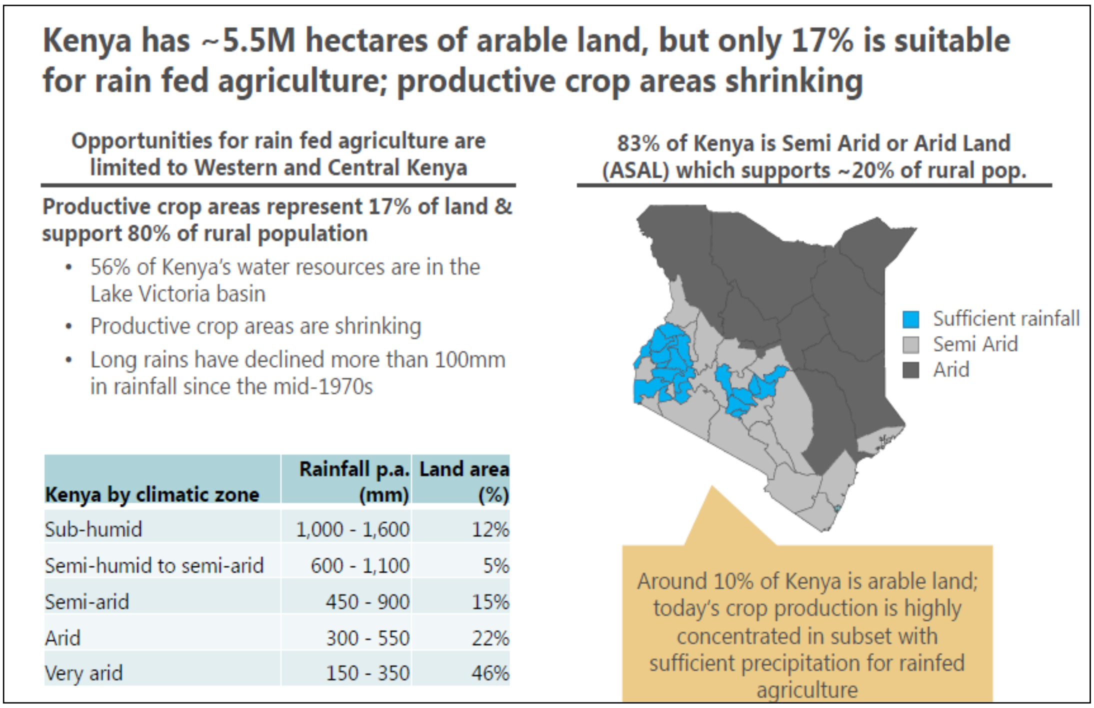


Figure 2.26. Distribution of arable land and drylands in Kenya. 2030 Water Resources Group (2016).

Soils

Soil types of Kenya

Soil is a natural resource that supports food production and numerous types of support to life on earth. The major soil types in Kenya are distinguished by parent materials, relief and other natural processes driven by climatic factors. Soils therefore vary in texture from sand to clayey type, in depth from shallow to very deep and in fertility from high to low. Diagnostic surveys of Kenyan soils on farm, including greenhouse and field tests have identified widespread deficiencies of nitrogen (N) and phosphorus (P) in different parts of the country (Okalebo *et al*. 1992; FURP 1994).

Land and soil make up the cardinal resource-base in any agricultural production system and numerous types of support to life on earth hence, their proper management is vital to ascertain if land is sufficiently available in good quality for sustainable agricultural production, soil composition on a farming enterprise, can make informed decisions on which crops to plant to achieve the highest and best quality yield. The nature of soil properties influences types of crops of grown, tillage methods, drainage/irrigation and fertilization, among many other factors that can impact productivity. A sustainable agricultural system is one that conserves land and soil resources, plant and animal germplasm, and is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable (Anon, 1991).

The major soil types and their distribution in Kenya as described by Gachene (2003) is illustrated in Figure 2.27 and Table 2.17).

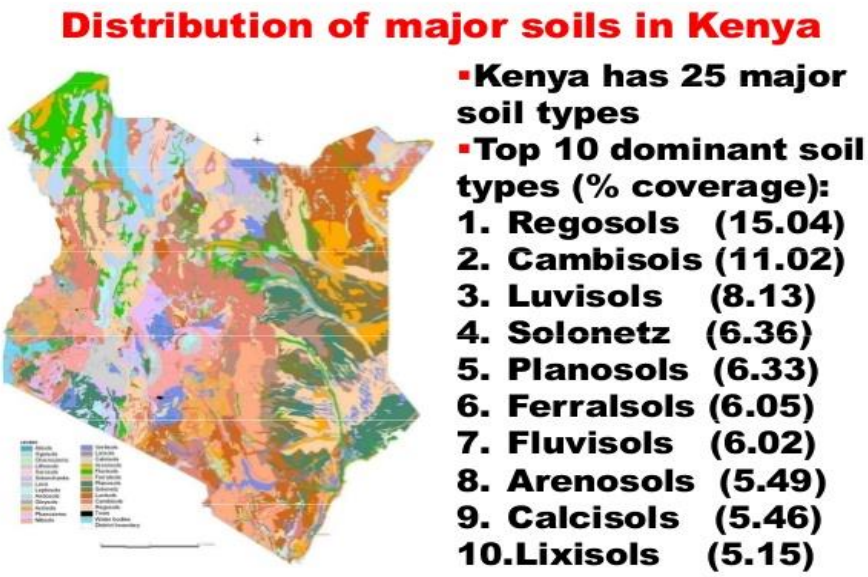


Figure 2.27. Distribution of soil types in Kenya.

Source: Gachene, 2003

Table 2.17. The major soil types in Kenya and their agriculture potential.

Soil Type	Characteristics	Agricultural Potential
Acrisol	It is a clay-rich soil. It has low levels of plant nutrients, high levels of aluminium, and high susceptibility to erosion	Silviculture and low-intensity pasture. If climate is permissible, then tea, coffee, and sugarcane can be supported
Andosol	Rich soil but may have problem of phosphorous fixation	Tea, wheat, orchids, vegetables, and potato
Calcisol	Desert soil with significant accumulation of secondary calcium carbonates	Low volume grazing
Cambisol	Young soil and good for agriculture	A wide variety of crops
Fluvisol	Occurs in periodically flooded areas such as alluvial plains, river fans, valleys, and tidal marshes	Paddy rice and many dry land crops
Ferralsol	Good soil physical properties but low in nutrients and strong P fixation	A wide variety of crops and soybeans
Leptosol	Shallow soil over continuous rocks	Wet season grazing and some tree crops
Luvisol	Soil with a subsurface horizon of high activity clay accumulation and high base saturation. Susceptible to erosion	A wide variety of crops
Lixisol	Soil with a subsurface horizon of low activity clay accumulation and high base saturation. Susceptible to erosion	Low volume grazing
Nitisol	Deep well-drained soil with stable structure and good nutrient content	A wide variety of food crops, coffee, and pineapple
Phaeozem	Porous fertile soil. Susceptible to erosion	A wide variety of crops
Regosol	It is a very weakly developed mineral soil in unconsolidated materials with only a limited surface horizon having been formed. It has low moisture retention	Small grains, grazing, fruit trees, groundnuts, and cassava

Source: https://www.infonet-biovision.org/EnvironmentalHealth/Kenyan-Soils/

Poor soil health and nutrient decline are the major constraints to agricultural production in Kenya. Among the root causes of this includes poor availability, access and low adoption of Integrated Soil Fertility Management (ISFM) inputs, knowledge, information and technologies (KIT). Due to continuous cultivation without adequate nutrient replenishment, there has been nutrient depletion in agricultural soils.

According to Kenya Soil Health Consortium (2014), the challenges in soil health management include:

- *High cost of ISFM inputs:* Currently, the cost of 50 kg bag of DAP fertilizer costs between KES 3,000 and 4,500. With the recommended rate of 4 bags per ha, a farmer requires between KES 12,000 and 18,000 per ha respectively to apply the recommended fertilizer rate. Similarly, recommended rates of organic fertilizer are between 5-10 tons/ha which costs the farmer between KES 7,000 to 16,000. This is too expensive for most smallholder farmers to afford.
- *Lack of coordination in ISFM research and development pogrammes*: There are many actors (Universities, National Research Institutions and International Research Organizations such as CGIAR centers, and others) in Kenya engaged in ISFM research and development, but they work in isolation resulting in duplication of work, waste of resources and often conflicting ISFM technology
- *Uncoordinated dissemination of ISFM technologies in Kenya*: Both public and private organizations are involved in the dissemination of ISFM technologies aimed at reaching as many farmers as possible. However, the dissemination process has become disjointed with some actors using less effective ISFM dissemination approaches. This therefore requires urgent steps to be taken to streamline the dissemination of ISFM technologies to improved adoption. Inadequate funding for ISFM research for development and extension Funding of ISFM research for development and extension is mainly by donors who work independently of the National Agricultural Research Systems (NARS) and in isolation.
- *Scattered data –due to lack of databases:* The many players in ISFM research have generated good ISFM technologies. However, these technologies are found in different institutions such as KALRO, Universities, other research institutions making it difficult for end users to access them.

Water resources

Kenya is classified as a water-scarce country. The natural endowment of renewable freshwater is currently about 21 BCM (billion cubic meters) or 650 m^3 per capita per annum. By 2025, Kenya is projected to have a renewable freshwater supply of only

235 m^3 per capita per annum. About 40% of the renewable freshwater has potential for development. The remaining 60% is required to sustain the flows in rivers so as to ensure ecological biodiversity and acting as a reserve for development beyond the timeframes of the strategies. Kenya’s safe yield of surface water resources is 7.4 BCM per annum and the safe yield of groundwater about1.0 BCM per annum. The current water abstractions are only a fraction (13% -19%) of the assessed safe yield or potential for development, indicating an extremely low level of development.

Increasing the productivity of agricultural water use in Kenya is a national priority, given the country’s low water endowment, growing population, and changing climate. Expanding the use of modern irrigation technology, such as drip and sprinkler systems, remains central to achieving water productivity because of the potential for such systems to increase yields relative to water withdrawals. The total ground water resources in Kenya is estimated at about 619 million cubic meter (Pavelic *et al.,* 2020) However, these relative abundant ground water resources remain underutilized, with less than 5% of the water used for irrigation coming from groundwater (Figure 2.28). The challenge is therefore to increase the amount of available water that is “harvested” for agriculture. Such water harvesting can be done at the field, farm or watershed level (Business Daily, 2019; Joshua *et al.,* 2012).

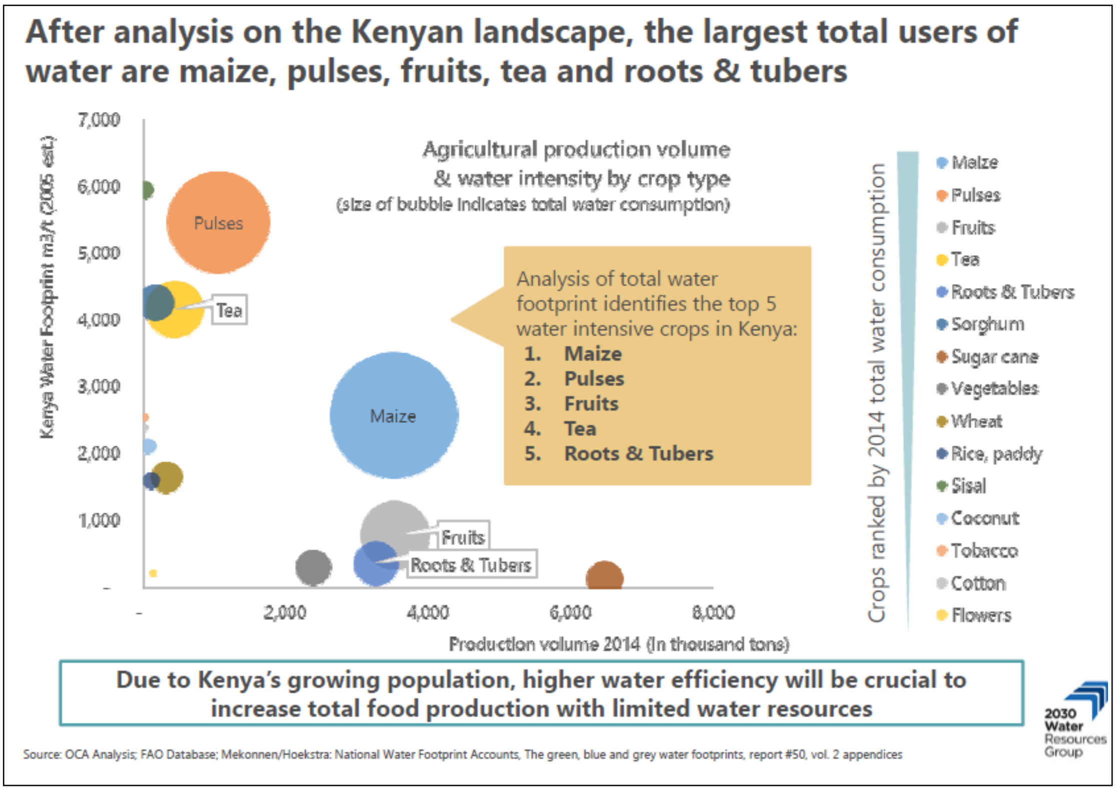


Figure 2.28. Water footprint for some selected crops in Kenya.

The degradation of catchment is causing increased runoff, flash flooding, reduced infiltration, erosion and siltation and this is undermining the limited sustainable water resources base in the country. The main causes of catchment degradation are poor farming methods, population pressure (forest excision for resettlement) and deforestation (for agricultural land and fuel wood). Catchment degradation will invariably affect surface water availability as rivers and reservoirs will dry up, with far reaching implications on agricultural production.

Gender and agriculture in Kenya

World Bank estimates that women make up between 42% and 65% of the agricultural labour force in the world (World Bank, 2014). In Kenya, as in many parts of the world today there is an increasing trend towards what has been called the feminization of agriculture. Women play a very significant role in agricultural production in Kenya. However, they are accorded little attention. Despite women's important role in the agricultural sector, however, empirical evidence shows that they face a number of constraints and lag behind men with regard to agricultural productivity in Kenya including other countries in Sub Saharan Africa due to the gender inequalities that persist in respect of access to, control over and utilisation of productive resources such as land, livestock, labour, education, extension and financial services, and technology (Slavchevska, 2015).

For instance, Land is considered the most important household asset for households that depend on agriculture for their livelihoods (FAO, 2011). However, across all developing regions of the world, including Kenya women are consistently less likely to own or operate land; they are less likely to have access to rented land, and the land they do have access to usually be of poorer quality and in smaller plots (Onyalo, 2019). Furthermore, a study by African Women's Studies Centre (2014) in Kenya found out that only 20.7% women own land compared to 43.8% of men. Additionally, legal regulations and customary laws in Kenya often restrict women's access to and control over assets that can be accepted as collateral such as land. Biased land inheritance rights often favour male relatives, leaving both widows and daughters at a disadvantage (Onyalo, 2019). Finally, lack of inadequate information on the level of women participation in agricultural production has helped to underestimate their importance in agricultural production and hence led to their neglect in sector development (Onyalo, 2019).

Vulnerability and impacts of climate change to the agriculture sector

The agricultural sector is highly vulnerable to extreme weather events, climatic shocks, climatic changes and variability. Climate change is creating further stresses on food and water supply while further degrading the environment. These impacts are likely to increase the vulnerability of farming systems, thus weakening coping strategies and resilience. Innovative measures are therefore needed to help farmers and consumers cope with the changes in emerging and projected climatic patterns.

Vulnerability in this context reflects on impact of climate change and variability on agriculture sector. According to the Intergovernmental Panel on Climate Change (IPCC), the term vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt[iv]. Thus, measuring and mapping vulnerability" is the first priority for supporting adaptation decision-making[v].

Three elements - exposure, sensitivity and adaptive capacity – are used in assessing the vulnerability of agriculture[vi] to climate change and variability in Kenya. Climate exposure indicators are developed from historical climate data[vii] (PPTAV, PPTCV, TTREND), and for sensitivity and adaptive capacity indicators, the Centre for International Earth Science Information Network[viii] (CIESEN) and Demographic and Health Survey (DHS) spatially interpolated data together with the Department of Resource Surveys and Remote Sensing (DRSRS), Regional Centre for Mapping of Resources for Development (RCMRD) (Table 2.18 with details of the indicators adopted).

Table 2.18. Indicators utilized for vulnerability assessment

Component	Indicator Code	Data Layer (Input)	Data format (original)	Data Source
Exposure	PPTAV	Average annual precipitation (January – December 1981 – 2019)	Raster	CHIRPS blended satellite- station precipitation
	PPTCV	Inter-annual coefficient of variation (CV) in precipitation (1981 - 2019)	Raster	CHIRPS blended satellite- station precipitation
	TTREND	Inter seasonal Temperature trend (1981-2019)	Raster	MODIS Land surface Temperature
	FLOOD	Flood Frequency (1999- 2019)	Polygon UNEP/UN SDIR grid	
Sensitivity	CARB	Soil Organic Carbon / Soil Quality (1961-2015)	Raster	ISRIC/AFSIS
	MALA	Malaria Stability Index (2018)	Map	MALA (Mapping Malaria Risk in Africa)
	POVI	Poverty Index (2010-2018)	Raster	Afri-POP
	MARK	Market Access (travel time to major cities)	Raster	Afri-POP DHS
Adaptive Capacity	WATER	Access to Improve Drinking Water	Polygon	DHS – GAHI
	IRRI	Irrigated areas (area equipped for irrigation) (1990-2019)	polygon	FAO
	ANTH	Anthropogenic Biomes	Polygon	CIESEN – SEDAC

Climate exposure

Figure 2.29 is developed from the analysis of these indicators using the ArcGIS platform.

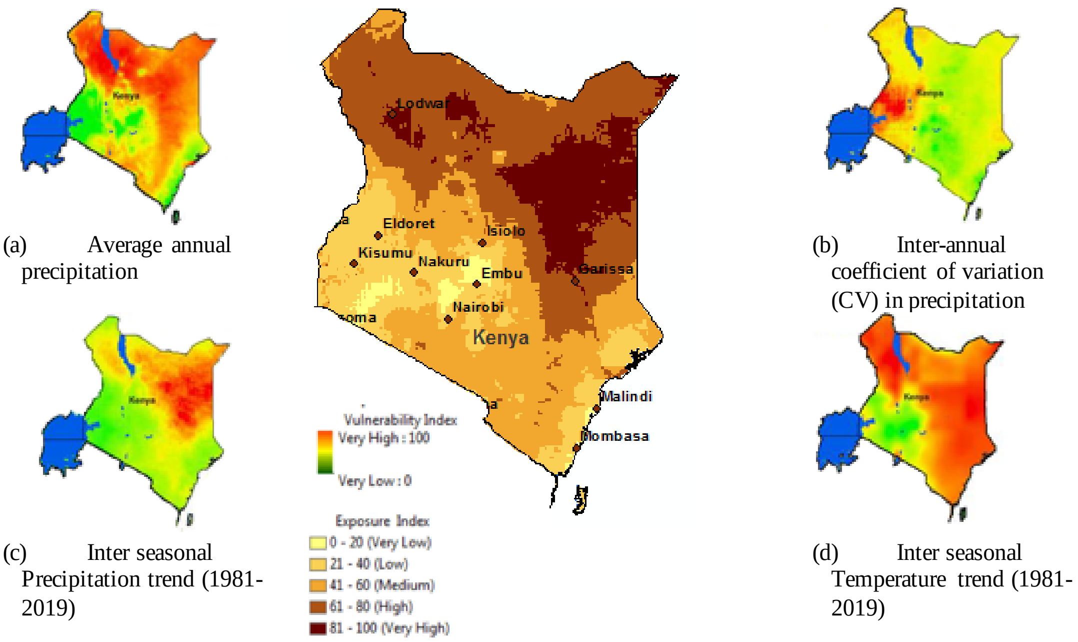


Figure 2.22. Overall exposure index (score).

Kenya's exposure to climatic shocks reflects the west to east gradient of increasing vulnerability. Most noticeably, the annual average precipitation (PPTAV) and the inter - annual coefficient of variation of precipitation (PPTCV) layers adopt this pattern with the western, central and coastal parts registering very low to low exposure to climatic extremities while northern and eastern Kenya being the worst-hit regions. The entire country receives temperatures in the scale of high to very high except for the central and western parts. All in all, the precipitation trend registered the least influence in the overall exposure score (Figure 2.30). Overall, for the 38 year period (1981 - 2019), most parts of Kenya have been exposed in a range of low to medium classes of climatic shocks.

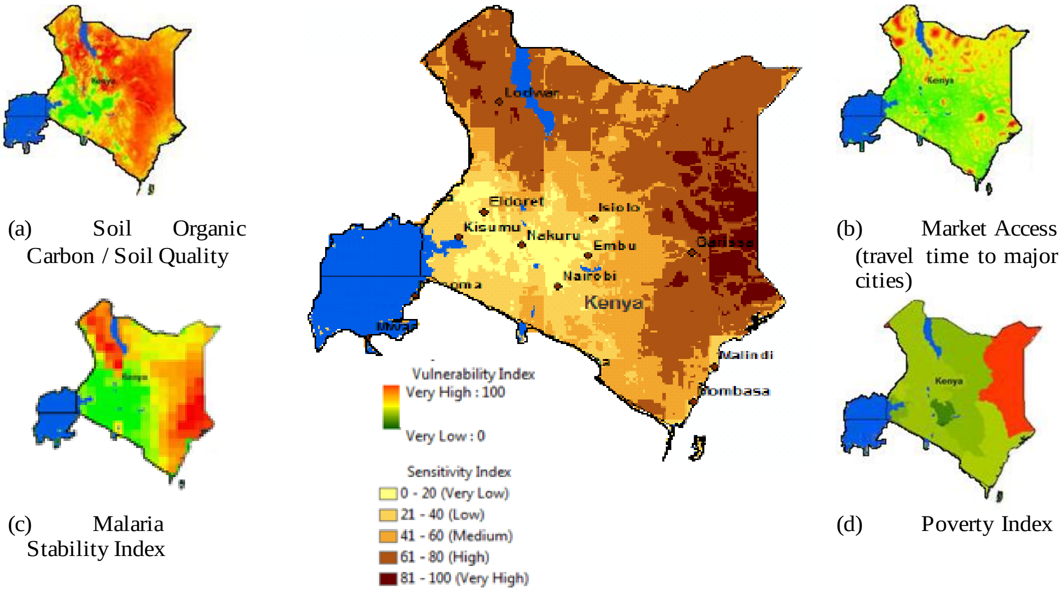


Figure 2.30. Overall sensitivity index (score).

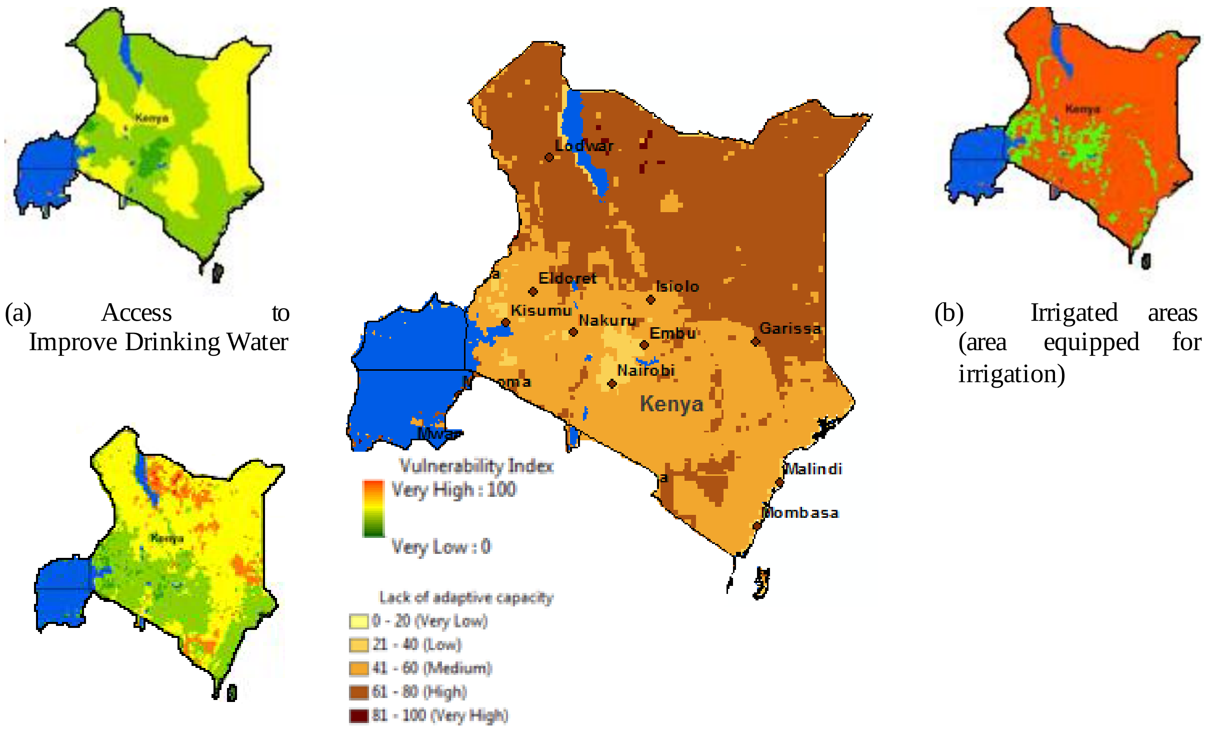
Climate sensitivity

High sensitivity is prevalent in the rangeland corridors of the northern and eastern region of Kenya from Lodwar all the way to Garissa revealing strong influence of high poverty rates and poor soil fertility (low organic carbon) in determining the high sensitivity scores of these regions. It is important to note that these rangelands are predominantly occupied by the pastoral communities' hence further livestock sensitivity analysis is necessary.

There is a considerable comparison between the exposure score (Figure 2.29) and the sensitivity score (Figure 2.30). In both scenarios, the most affected areas (severely exposed and highly sensitive) were also found to be the marginalised areas in the country, the ASALs.

Lack of Adaptivity to climate shocks

Majority of Kenyans (35 – 50%) lack the adaptive capacity to climatic shocks when adaptivity score is based on access to improve drinking water; areas equipped for irrigation and anthropogenic biomes. Note that regions which had irrigation as an alternative to rain fed agriculture registered lower lack of adaptive capacity scores (Figure 2.31).



(a) Access to Improve Drinking Water

(b) Irrigated areas (area equipped for irrigation)

Figure 3.31. Overall adaptivity index (score).

Overall vulnerability

The overall vulnerability map that averages the rescaled values from the exposure, sensitivity, and adaptive capacity components but with scores grouped in five quintiles, such that each quintile represents an equal area on the map, instead of five equal intervals (Figure 2.32). The same information but in the form of histograms show how each component was distributed in the country.

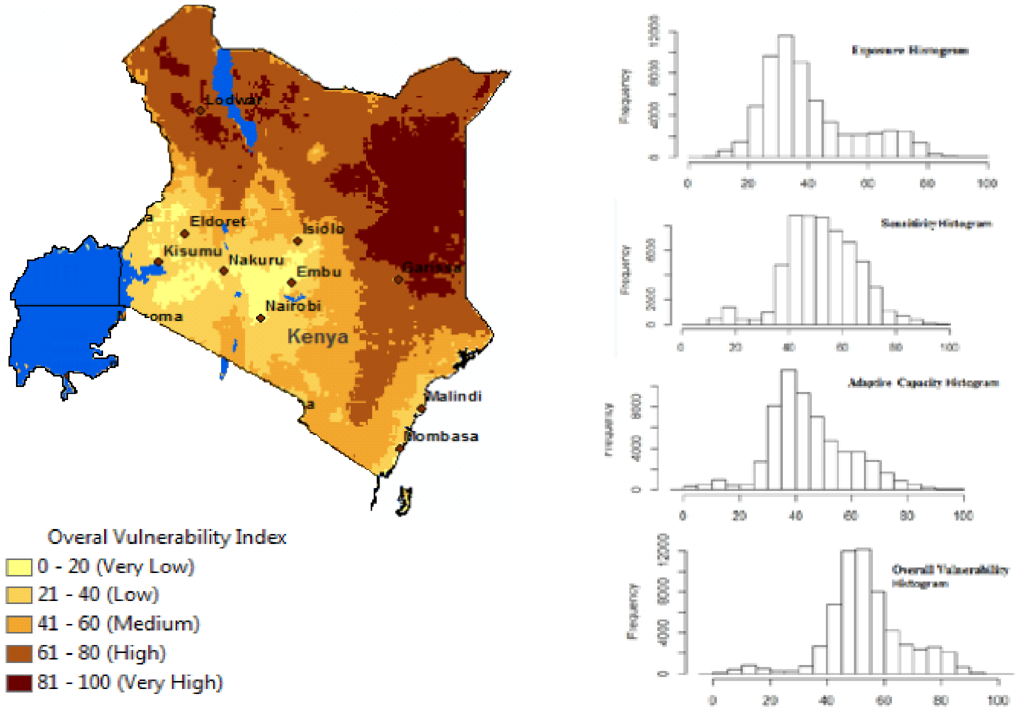


Figure 2.32. Overall vulnerability index (Left) and Component histograms (Right).

Generally, vulnerability proceeds in a south–north gradient, with lowest vulnerability in the central parts and gradually increasing vulnerability northward towards areas north of Garissa town with the exception of some pocket areas of moderately low vulnerability most notably around major cities.

The distribution of each component in the country is illustrated in Figure 3.32 (right panel), and the overall impact it had in the final vulnerability score in the 5 classes was used. From the histograms, it comes out clearly that not much of country is exposed to climatic extremities since most areas registered a score of between 25 to 40 (Low to Medium). This was not the case with sensitivity and adaptive capacity. The most worrying bit was that the sensitivity scores for most areas in the country ranked between medium to very high (40 - 70). It is hence established that climate-related vulnerabilities in the country was influenced more by the high to very high sensitivity of most marginalised landscapes in the region, especially the rangelands, coupled with a lack of adaptive capacity.

Sources of emissions from the agriculture sector

In 2015, 40% of Kenya's total emissions were produced by the agriculture sector, predominantly CH_4 from ruminant farm animals, e.g. dairy cows and sheep, and

N_2O from animal excreta and nitrogenous fertilizer use[ix.] The current level of emissions from the agriculture sector is 75.9% above the 1995 level. Agriculture was the leading source of GHG emissions, contributing 40% of total emissions, Land-Use change and forestry (LULUCF) sector contributing 38%. Agriculture and LULUCF sectors dominate the share of Kenya's total greenhouse gas emissions.

Emissions for different areas of the agricultural sector for 1995 and 2015 has been documented using data from MoALFC (Figure 3.33). The largest emissions are caused by enteric fermentation, land conversion to grassland and cropland. The land converted to forest land are good removals of CO_2. Direct and indirect N_2O emissions from managed soil comprise nitrogen inputs from crop residues, application of synthetic nitrogen fertilizers and land-use practices associated with land-use change. Both sources produce the largest emissions under the IPCCC category 3C. The observed increasing trends of both direct and indirect N_2O emissions from managed soils could be linked to the Government of Kenya`s fertilizer subsidy programme and encroachment of grasslands and forests for agricultural use. Rice cultivation is significantly low. Other emissions from crop farming play a negligible role.

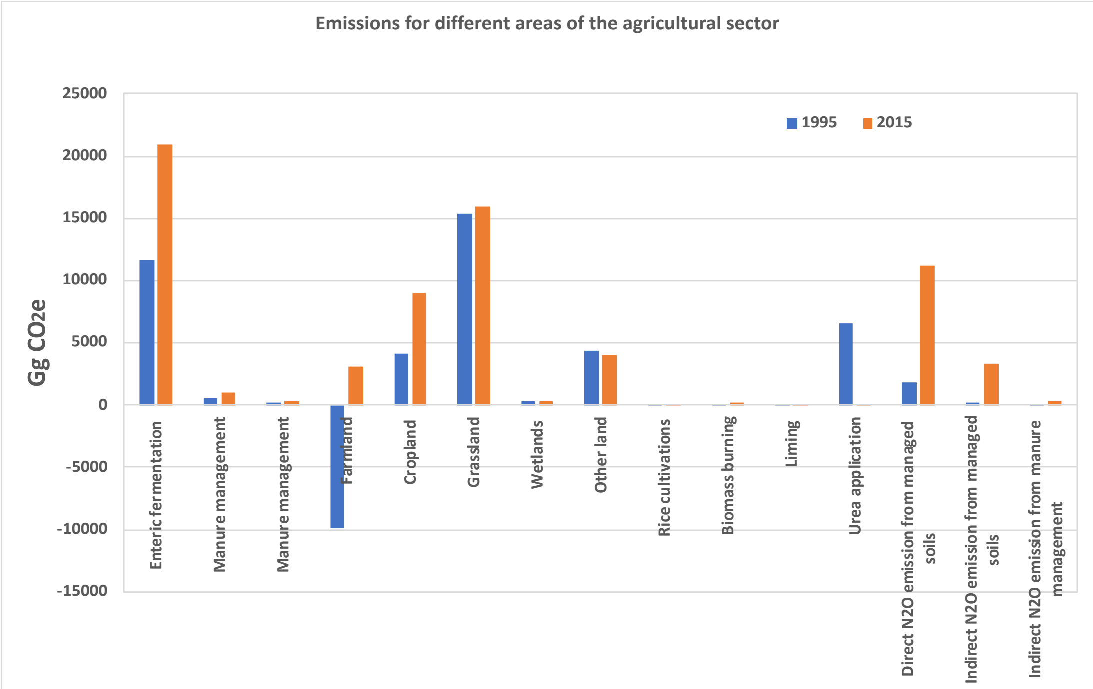


Figure 2.33. Emissions for different areas of the agricultural sector.

The AFOLU sector is the major source of CO_2 emissions that have fluctuated over the 20 year period, mainly due to the effects of land use change, but overall there appeared to be an increasing trend. The main cause of this increase was due to the rise in emissions in land use change, livestock and agricultural soils sub-categories. The 2015 estimate in this inventory was 50% higher than the 1995 inventory estimates (Table 2.19).

Table 2.19. Greenhouses Gas Emissions trends in AFOLU sector sub-categories (Source: GoK 2020)

Year	1995	2000	2005	2010	2015	% change 1995-2015
Livestock (3A)	12460.4	11459.8	13717.3	15326.3	22258.0	79%
LULUCF(3B)	27038.39	54215.50	26177.59	29026.74	35274.11	30%
Aggregate sources and non-CO_2 emissions sources on land (3C)	8758.5	8468.9	9511.0	10813.1	15073.8	72%
Total AFOLU Gg CO_2eq	48257.3	74144.2	49405.8	55166.2	72605.9	50%

Emissions from livestocktotalled 22,258 Gg-CO_2eq, with most GHG emissions arising from dairy cattle (primarily in zero-grazing) both from enteric fermentation as well as manure management. Livestock emissions represented 23% of all greenhouse gas emissions in 2015. Emissions in this sub sector have risen from 12,460.4 in 1995 to 22,258 Gg-CO_2eq in 2015, representing 78.6% rise in emissions in the sub-sector. The increase is primarily attributable to an increase in CH_4 emissions from enteric fermentation[18].

Emissions of CH_4 from enteric fermentation dominated the sub-sector contributing about 94% share of emissions in the category Manure Management; contributed 4% from Methane (CH_4) and 2% from Nitrous Oxide (N_2O) emissions from livestock (Table 2.20).

Table 1.20. Livestock Emissions by source category (in Gg-CO2eq), 1995 - 2015 expressed as GgCO2eq.

YEAR	1995	2000	2005	2010	2015	Change 1995-2015
3.A.1 - Enteric Fermentation CH4 *(Gg-CO_2eq)*	11703.4	10722.1	12843.5	14383.0	20920.0	78.8%
3.A.2 - Manure Management CH4 *(Gg-CO_2eq)*	533.6	513.6	611.9	670.5	965.3	80.9%
3.A.2 - Manure Management N2O *(Gg-CO_2eq)*	223.4	224.2	261.9	272.9	372.7	66.8%
Total 3A-livestock Emissions *(Gg-CO_2eq)*	12460.41	11459.80	13717.26	15326.32	22258.01	78.6%

Future climate scenarios

Scenarios are plausible snapshots of the future that help focus thinking on key factors driving long-term changes and identify emerging opportunities, challenges and threats. Regional Climate Models (RCM) have been relied upon to give high-resolution climate projections at a local scale for impact assessment and development of adaptation strategies[x]. The RCM models are used to downscale the Global Climate Models (GCMs), which are used in the preparation of the Intergovernmental Panel on Climate Change (IPCC) assessment reports[xi]. To provide local scale information for impacts assessment, vulnerability analysis and adaptation strategies, projection of future climate change must be of high resolution[xii].

The Coordinated Regional Climate Downscaling Experiment (CORDEX) program, initiated by the World Climate Research Program (WRCP), provides an excellent opportunity for generating high resolution projections useful for the assessment of future impacts at national levels[xiii]. The African CORDEX RCMs have historical (1960-2019) and future (2020-2100) climate data available at 50km resolution downscaled under Representative Concentration Pathways (RCPs). The Intergovernmental Panel on Climate Change (IPCC) recommends the use of Representative Concentration Pathways (RCPs) to analyze climate change.

The future climate scenarios of Kenya analyzed using an ensemble (average) of 10 CORDEX RCMs over time slices of the 2030s, 2060s and 2070s provided information on the expected magnitude and impacts using 1981 – 2010 as the base period for RCPs 2.6, 4.5 and 8.5. The projected climate change signals for each time window are calculated as the difference between the future time windows (averages calculated over 30 years) and the base period.[xiv] The RCP 2.6 represents an optimistic projection characterized by a very low concentration and emission levels of greenhouse gases. RCP 4.5 represents a moderate emission scenario where international communities are working on limiting emissions with the limited implementation of climate change policies. RCP 8.5 represents a pessimistic projection with high levels of concentrations, and assumes no implementation of climate change policies. Validation of these 10 CORDEX RCMs over the country and eastern Africa region had previously been undertaken[6,9].

Projected Future Temperature

The ensemble mean of the 10 CORDEX RCMs showed mean surface temperature increase range of 1 °C to 1.5 °C by 2030, 1.5-2.0°C by 2060s, 1.5-5.0°C by 2090s (**Figure 3.33**) with the greatest warming generally under RCP8.5 scenario. Rising temperatures trend is expected to continue in Kenya in all seasons. This concurs with the IPCC Fifth Assessment Report[xv], which indicated that during this century, temperatures in the African continent would rise more quickly than in other land areas, and that this would particularly be observed in more arid regions.

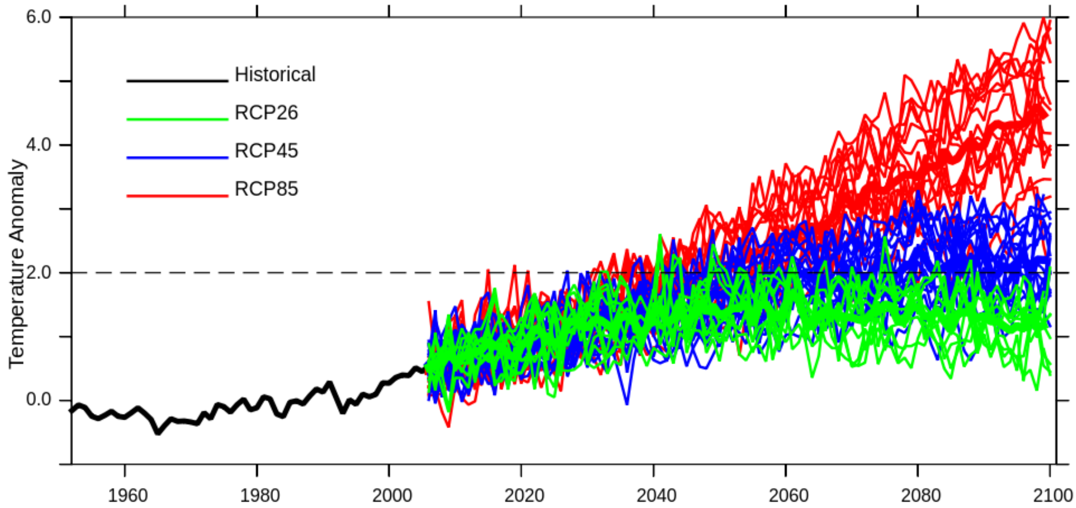


Figure 3.33. Projection of mean surface temperature over Kenya under different scenarios (Baseline 1981-2010).

Temperature rise is projected across all seasons in Kenya, but particularly from March to May (Figure 3.34 left panel). Variations exist between locations, with a higher rate of warming observed in October to December season (Figure 3.34 right panel). The surface temperature trends in some Counties show warming of more than 2.5 °C by 2030 under all the RCPs that surpasses the Paris Agreement that aims at strengthening the global response to the threat of climate change, by keeping the rise in global temperature during this century to well below 2 °C above pre-Industrial levels.

IPCC 2014 presents strong evidence that surface temperatures across Africa have increased by 0.5 – 2 °C over the past 100 years, and from 1950 onwards, climate change has altered the magnitude and frequency of extreme climate events. The frequency of cold days, cold nights, and frost, has decreased; while the frequency of hot days, hot nights, and heatwaves, has increased.

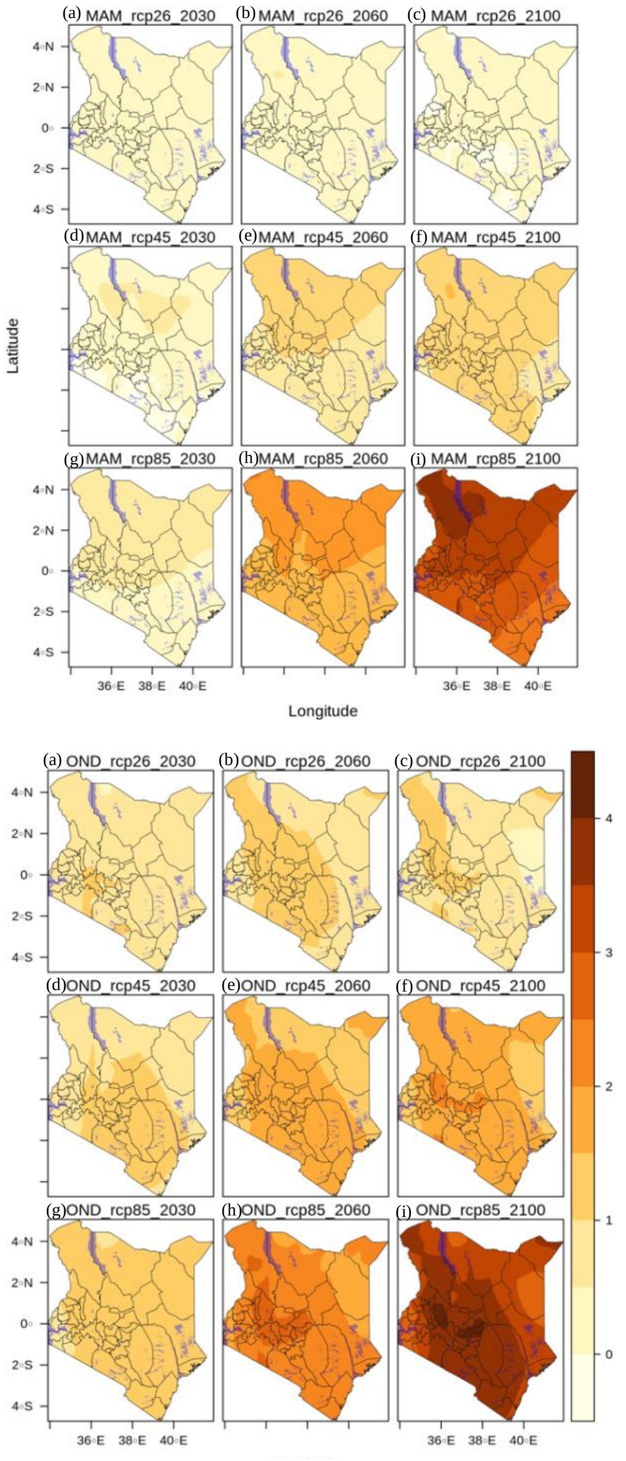


Figure 3.34. Projected mean surface temperature change in Kenya by 2030, 2060 and 2100 for MAM (left panel) and OND (right panel) season under RCPs 2.6, 4.5 and 8.5.

Projected Future Rainfall

The projected rainfall for RCP4.5 indicates that the October–December (OND) short rains will increase in many counties of Kenya except for the Lakes Victoria and Turkana basins. RCP2.6 portends dryness over most counties (Figures 3.35). In comparison, the MAM long rains will be extremely low (Figure 3.35) for RCP 2.6, and 8.5 with most of northern Kenya having rainfall deficits whilst southern Kenya will have a slight increase of rainfall. During the dry season June–September (JJAS), the rains are projected to decrease for RCP 2.6 and 8.5, whilst increase for RCP 4.5.

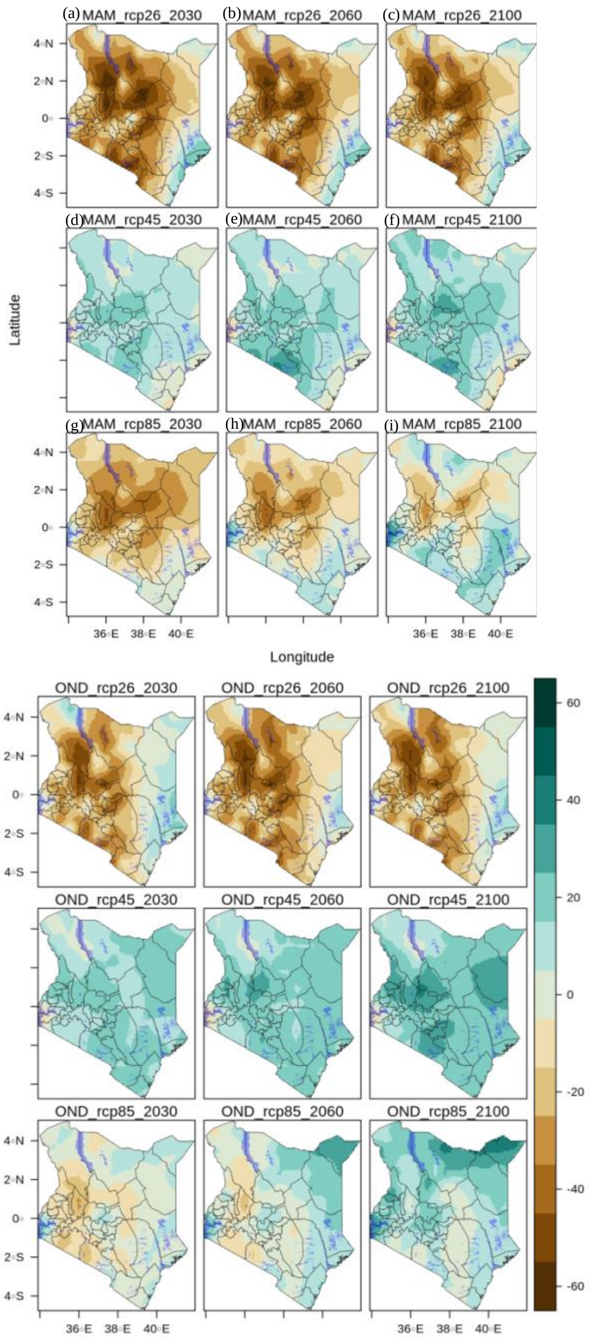


Figure 3. Projected rainfall changes (%) in Kenya by 2030, 2060 and 2100 for MAM (left panel) and OND (right panel) seasons under RCPs 2.6, 4.5 and 8.5.

In RCP 4.5, the annual rainfall is projected not to change much, but both MAM and OND seasons are relatively wetter (Figure 3.35). The projected rainfall for RCP 2.6

and 8.5 are generally similar as MAM and OND rainfall seasons are expected to be drier (more so RCP 2.6) in several parts of the country. This will translate into an overall decrease in annual rainfall for the county.

The analysis indicates that precipitation projections are more uncertain than temperature projections; suggesting that by the end of the 21st century, the country will have a wetter climate, with more intense wet seasons and less severe droughts.26

A warmer future is projected in all models, but a wetting trend is projected in most areas under RCP 4.5 during the short rains while mixed signals will be obtained for RCP 8.5. The trend in rainfall is location-specific with some pocket areas getting wetter while others dryer.

Enabling policy environment

The Government of Kenya has put in place policies that support agricultural development and response to the effects of climate change. These include: National Livestock Policy 2015; National Oceans and Fisheries Policy 2008; National Agricultural Research System Policy, 2012; National Agricultural Sector Extension Policy 2011;the Kenya Climate-Smart Agriculture Implementation Framework Programme (2018-2027); Strategic Plan for Agricultural and Rural Statistics 2015-2022; and the Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019 – 2029. Others are the National Climate Change Policy (NCCP) 2018; National Adaptation Plan (NAP) - 2015-2030; National Climate Change Response Strategy (NCCRS); and Nationally Determined Contributions (NDCs).

Constraints to agricultural development and growth

The Kenyan agriculture sector continues to be a fundamental pillar for sustainable development and poverty reduction. However, it continues to face challenges and emerging constraints at the global, regional and national levels that require to be addressed. Constraints that affect agriculture development at national level have been well analyzed in the Agricultural Sector Development Strategy (ASDS: 2010 - 2020), Kenya Vision 2030 and its second Medium Term Plan (2013-2017) and

Agriculture Sector Strategy 2013-2017 and ASGTS (2018). The constraints are categorized into three as follows: global, regional and national.

Global constraints

Thecountry’sagriculturalstrategiesfocusonmovingfromsubsistencetocommerciallyori entedand competitive agriculture. Even though great improvements have been noted in the last decade, more still needs to be done especially to address the global constraints that hinder that transformation. These include:

- *Unfavourable international terms of trade:* Developed countries in particular, continue to impose prohibitive tariff and non-tariff barriers that are unfavourable to be complied with given the small-scale nature of agriculture in the country. The protracted negotiations of the Economic Partnership Agreements (EPAs) have not be very successful as initially the countries in the East African Community were negotiating as a block. Kenya was disadvantaged as it is the on country in the EAC that is not a Least Developed Country (LDC).
- *Rising costs of inputs:* The high cost of agricultural inputs such as fertilizers and agrochemicals is as a result of the rising costs of production as a result of unpredictable high cost of crude oil. Agricultural machinery and equipment are also very expensive as they have to be imported.
- *Climate change:* The effects of climate change on agriculture and livelihoods have devastating consequences on food and nutrition security, environment, society and wider economy and Kenya is no exception. Since 1993, Kenya has declared six national disasters due to droughts that have had devastating effects on the country’s agriculture sector. Projections indicate an increase in the frequency and duration of droughts and a greater amount of annual precipitation falling during heavy rainfall events (USAID,2012).
- *Global economic recession:* In the recent past, the world economy has been faced with an economic slow-down with signs of possible recession. The recent melt down in banking and the flow of money in the United State of America (USA), Europe and Asia has also presented new and worrying dimensions to global finance and by extension Kenya’s agriculture sector that is export oriented.

Regional constraints

Weak Regional Integration and Cooperation: The East Africa region contributes less than 10% of international trade and remains a net importer of both industrial goods and agriculture commodities. Regional cooperation has remained difficult some of the countries continue to apply restrictive barriers. It is hoped that with the establishment of the African Freed Trade Area (AfCFTA) some of these barriers will be removed resulting in enhanced free trade across Africa. Kenya is also a member of other regional economic communities such as the Common Market for Eastern and Southern Africa (COMESA) and Intergovernmental Authority on Development (IGAD).

National constraints

Inadequate budgetary allocation: Insufficient budgetary allocation to the agricultural sector is a key constraint. In 2003 under the Maputo Declaration, African Heads of State committed to allocate 10 per cent of their annual budgets to the agricultural sector. This insufficient allocation has reduced human resources and service delivery by Government institutions.

Frequent extreme weather events (droughts and floods): Over the last three decades, the frequency of droughts and floods has increased, resulting in crop failures, emerging livestock diseases as well as loss of livestock and fisheries.

Low deployment and diffusion of modern technology. Use of modern technology in production is still limited. Inadequate research–extension–farmer linkages to facilitate demand-driven research and increased use of improved technologies continue to hinder efforts to increase agricultural productivity. In addition, the rate of deployment and diffusion of agricultural mechanization remains low.

High cost and increased adulteration of key inputs. The cost of key inputs such as improved seed varieties, pesticides, fertilizer, drugs and vaccines is high for resource-poor farmers. Such high costs lead to low application and adulteration of inputs.

Limited capital and access to affordable credit. Farming is considered highly risky by the formal banking sector. The formal banking system is just beginning to develop credit facilities particularly suited to small-scale farming. Without credit, farmers are hard pressed to finance inputs and capital investment. A number of microfinance institutions are operating but they tend to increase the cost of credit, reach only a small proportion of smallholder farmers, and provide only short-term credit.

Post-harvest crop losses. There have been high levels of waste due to post-harvest losses occasioned by pests and lack of proper handling and storage facilities. There is increasing incidences of new pests which many smallholder farmers are nor accustomed to and cannot control. For instance, post harvest losses due to afflatoxins affecting maize is now very common across the country.

Heavy livestock losses due to diseases. Livestock diseases are on the increase. The prevalence of diseases such as foot and mouth, chronic bovine pleuropneumonia, lumpy skin disease, trypanosomiasis, east coast fever, brucellosis, *pestes des petits ruminants (PPR*), contagious caprine pleuropneumonia, rabies, Newcastle disease, and *Gumburo* disease continue to be a challenge.

Land subdivision, land use and low and declining soil fertility and productivity. The rising population density has contributed to the subdivision of land to uneconomically small units. The average of land owned by most farmers ranges them from 0.2 to 3 ha with only 60% being put to productive use. The small handholding impedes mechanization. Reduction of fallow periods and continuous cultivation have led to rapid depletion of soil nutrients, declining yields and environmental degradation. Similarly, the production level for most fish and livestock products is below potential.

Weak implementation of the legal and regulatory frameworks: The sector has made strides in consolidating agriculture policies and legislation. However, some policies and legislations remain out-dated and inconsistent with the Kenyan Cconstitution (2010) and where the policies exist, there is implementation is weak.

Weak surveillance on offshore fishing. The weak capacity to effectively monitor and enforce compliance and regulations governing the exploitation of offshore territorial waters has limited Kenya's ability to fully exploit the offshore fishing potential. Recently, Kenya established the Kenya Coast Guards as an agency to be responsible for the surveillance of the country's coastline.

Inadequate infrastructure. Poor rural roads and other key physical infrastructure have led to high transportation costs for agricultural inputs and products. This has reduced farmers' ability to compete. Electricity in rural areas is often not available or is expensive, leading to reduced investment especially in cold storage facilities, irrigation and processing of farm produce.

Inadequate storage and processing facilities. Inadequate storage facilities constrain marketability of perishable goods such as fish, dairy products, beef and vegetables. Lack of fish-processing facilities close to Lake Victoria and the coastal area (Mombasa) has limited the extent of exploiting fish resources. The country exports semi-processed, low-value produce, which accounts for 91 per cent of total agriculture-related exports. The limited ability to add value to agricultural produce coupled with high production costs make exports less competitive.

Inadequate markets and marketing infrastructure. While Kenya's agriculture is better developed than that of most countries in Sub-Saharan Africa, the domestic market is too poorly organized to take advantage of the regional market. The local marketing information system has recently been established but has not been well utilized. The productivity of the agricultural sector is constrained by inefficiencies in the supply chain resulting from limited storage capacity, lack of post-harvest services and poor access to input markets.

High incidence of HIV and AIDS, malaria, water-borne and zoonotic diseases. The high incidences of these diseases and corresponding deaths have resulted in the loss of productive agricultural personnel and of the manual labour force with sustained farming knowledge, and have resulted in diversion of resources to treat these diseases.

Gender inequalities: Gender inequalities continues to impact negatively on household food security, sector performance and overall economic growth. These inequalities include: access to and control over productive resources; effective participation along the agricultural value chain and in agricultural service delivery.

Impacts of climate change on agriculture and adaptation response measures

Overview

Kenya has a complex and variable climate due to its topography and the influence of several regional and global climatic processes, including movement of the Inter-Tropical Convergence Zone (ITCZ), the El Niño Southern Oscillation (ENSO), and the Indian Ocean Dipole (IOD). These climatic processes, in combination with the country's topography, contribute to climatic regimes that range from warm and humid in the coastal regions to arid and semi arid in the interior. Almost 80% of Kenya receives less than 200 mm of rain per year and is classified as arid or semi-arid (ASAL). The country is highly vulnerable to climate change ranking 151 out of 181 countries in the ND-GAIN index (2017). Current climate projections showing that its temperature will rise up to 2.5°C between 2000 and 2050, while rainfall will become more intense and less predictable. For 2100 a warming ranging between 1.3°C and 3.9°C is likely, with some models showing an increase of 4°C by 2100. Increasing rainfall intensities will result in more frequent and heavier floods (accompanied by landslides) and simultaneously prolonged periods of drought.

Climate change is expected to affect all four dimensions of food security: availability, access, utilization and stability. Important crop production areas are expected to shrink if (seasonal) rainfall decreases (USGS and USAID, 2010). Moreover, productivity per hectare will change. Under a 3.5°C increase and a 20% precipitation change by 2030, production in high potential areas will only face a small decrease or even an increase (up to 1%), but production in medium – and low-potential areas will decrease by 21.5%. in the ASALs especially, yields may decline by 20% even if temperatures increase only by 2.5°C (Parry *et al.,* 2012).

Impacts of climate change on the agriculture sub-sectors

Crop sub-sector

Crop productivity is highly dependent on climate and weather under rain-fed agriculture, like in the case of Kenya. Climate change affects crop yields disproportionately depending on the different agro-ecological zones and production systems. For example, in high altitude regions such as the highlands where temperature (low) is the limiting factor for plant growth, a rise in temperature possibly will increase crop yield, but in lowland areas, will increase the risk of water stress (Thornton et al., 2009). Precipitation variability is expected to intensify the magnitude and frequency of flood and drought events that are both detrimental to crop production (Pachauri and Reisinger, 2007). These events will likely further decrease crop water availability and threaten the productivity of the rainfed agriculture system in Kenya. Water and heat stress are projected to temporally decrease the length of the growing season while spatially shrinking the suitable areas for agricultural production, especially along the boundaries of arid and semiarid regions (Thornton et al., 2009).

Data on economic losses in agriculture due to climatic risks are generally limited but available ones as compiled by UNISDR2 show that the highest losses were incurred in the year 2009 and 2010 was attributed to drought and the estimated crop losses was at over 150 million dollars (ATLAS, 2016) (Figure 3.1).

[2]http://www.preventionweb.net/english/hyogo/gar/2015/en/gar-pdf/Annex2-Loss_Data_and_Extensive_Risk_Analysis.pdf

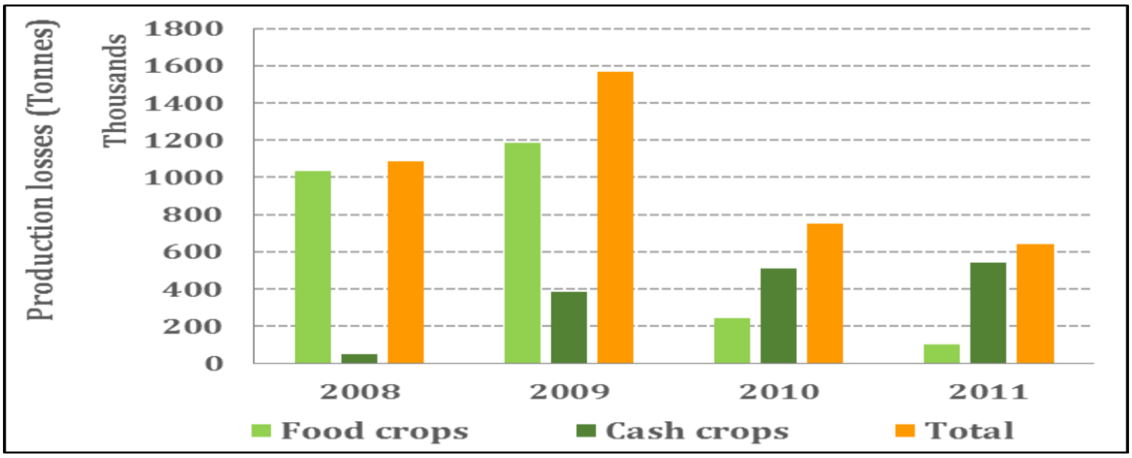


Figure 3.1. Production (tonnes) losses of food and cash crops.

Source WFP, 2016

Climate change is also projected to reduce the value of cropland by shifting high value agro-ecological zones to low value agro-ecological zones (Kurukulasuriya and Mendelsohn, 2008). Increased rainfall intensity is projected to accelerate the rate of soil erosion in the future (Adhikari *et al.,* 2015), further threatening the crop productivity.

Over the years smallholder farmers have tended to increase cultivated land instead of intensification as a coping mechanism to deal with low yields. Increasing agricultural production through land expansion is not sustainable as land is a finite resource. While crop intensification is the most appropriate approach for enhancing crop yields, this would require adoption of appropriate climate smart technologies and practices. Unfortunately, most of the smallholder farmers do not have access to climate smart technologies and inputs such as fertilizers, pesticides and improved seeds making it difficult to transform their farming practices.

Food crops

By 2030, nine out of 10 food crops will experience reduced or stagnant growth rates, while averaging prices will increase dramatically as a result, at least in part due to climate change (Figure 3.2). Further, simulations of the effects of different climate change scenarios on food insecurity and the results suggested that adverse climate change is likely to increase food insecurity in Kenya, with the greatest effect on maize insecurity, which is predicted to increase by 8.56% to 21% by the year

2100, other factors constant. Also, the results suggested that sorghum may improve (in terms of less food insecurity by the year 2050), followed by modest increases in insecurity by the year 2100. There is also a likelihood of modest increases in beans and millet insecurity (Mariera, 2015). In response to impact of climate change, farmers are shifting to fast maturing as well as drought-tolerant crop varieties including watermelons, tomatoes, okra, onions, butternuts, canola, traditional vegetables and beans.

Figure 3.2. Projected impacts of climate change in Kenya by 2030. Source: CIAT, 2015 and Tegemeo Institute, 2010

(a) *Maize:* Maize is the most important and widely consumed food crop in Kenya. It is the staple food crop for 96% of the population with 125 kg per capita consumption and provides 40% of the calorie requirements in Kenya (Omoyo *et al.,* 2015). The relationship between maize yield and climate variables has been established to indicate that maize plants tend to experience extreme sensitivity to water deficit, during a very short critical period, from flowering to the beginning of the grain-filling phase. Maize crops tend to have the highest water requirement during the critical period (flowering to beginning of grain filling) for two reasons: high water requirement, in terms of evapotranspiration; and high physiological sensitivity when determining its main yield components (Omoyo *et al.,* 2015). Since maize production in Kenya in largely rainfed, it relies on sufficient and timely rainfall throughout the life cycle of the maize plant. However, in maize growing areas in the country, there is high variability of rainfall amidst rising temperatures. In addition, the duration and amount of the long and short rains are changing. With the observed and projected changes in rainfall and temperature and over reliance on rain-fed maize farming, climate variability is expected to create a shift in maize production and yields (Onono et al., 2013). Analysis of trends in maize production reveals that the country is not self-sufficient due to low adoption of technologies, high pests and diseases incidence and unsuitable climatic conditions (Omoyo *et al.,* 2015).

(b) *Beans:* Bean is one of the important food security crops in the country, accounting for 17.9% of the total harvested area. Like maize, crop yield projections for beans vary depending on the regions and the specified climate scenario. Although, the magnitude of the change in yields varies under different scenario, most models project declines. Thornton *et al.* (2011) run a crop simulations for conditions in a 4^{o}C warmer world by 2090 using a mean of three emission scenarios and 14 general circulation model (GCM) and established that for Kenya alongside other East African countries, a mean yield loss of 47% is projected for beans. However, the disaggregated analysis predicts substantial yield increases for beans at higher elevations in Kenya's western highlands, up to average temperatures of about 20 - 22^{0}C, after which yield decline (DFID, 2012)

(c) *Wheat:* The optimum wheat-growing temperature of 15–20°C (Liu et al., 2008). A 1°C increase in temperature above norm reduces wheat yield by 3 - 10% (Brown, 2009; Wardlaw et al., 1989). As wheat has a lower optimum temperature than rice, maize, millet, cassava, and sorghum (Liu et al. 2008), many simulation studies have projected a significant impact on wheat yield compared to other crops in Kenya (Liu et al. 2008; Fischer 2009; Nelson et al., 2009; Ringler et al., 2010). For instance, Fischer (2009) projected 30%, 48%, and 72% yield reduction for rainfed wheat in eastern Africa by 2020s, 2050s, and 2080s, respectively, even considering carbon fertilization. Other projections have further indicated that even with adaptation actions, a 4°C rise in temperature will result in a 15% decrease in wheat production, particularly in low latitudes.

(d) *Rice:* The demand for rice in Kenya exceeds production and the gap between production and consumption is filled through importation. The current rice production is estimated at 150,000 metric tons from about 25,000 hectares of land, which meets only 20% of the total demand. The rice consumption in the country is projected to rise with increasing population and changes in eating habits (Atera *et al.,* 2018). Rice is produced both under irrigation and upland conditions in Kenya. Presently, about 78% of the total area under rice cultivation in Kenya is under irrigable ecosystem. Small quantities of rice are produced along river valleys especially in smallholder irrigation schemes. In the irrigable ecosystems, rice production involves continuous flooding. This system of rice production depends on a continuous supply of water for irrigation and soils with high water holding capacities. It is however important to note that these irrigated ecosystems are directly dependent on rainfall so that if there is water scarcity in times of drought it means that the schemes have to receive rationed water thereby reducing productivity (Atera *et al.,* 2018). The extent of climate change impact on rice production in Kenya is largely dependent on adopted production system. The temperature increases, rising seas and changes in rainfall patterns and distribution expected as a result of global climate change will lead to substantial modifications in land and water resources for rice production as well as the productivity of rice crops grown in the country.

(e) *Sorghum and Millet:* Sorghum and millet have been credited with novel characteristics of tolerance to drought, soil salinity and ability to withstand flash floods and high temperatures. The two exhibit better productivity in infertile soils in comparison to other cereals. They have short growth cycles, making use of short duration rains to attain full development. These two crops have been encouraged among the farmers in Kenya, especially dry sub-humid areas and medium-high altitudes. Generally, there is increasing trend in sorghum and millet production in the country, and this is expected to spread to high potential lands that are growing warmer and receiving reduced rain (Ogolla *et al.,* 2016). Despite their tolerance to climate change, the expected rise it temperature and severe droughts will compromise their productivity in the coming decades.

(f) *Cassava:* Cassava is more resilient to climate change due to its tolerance of high temperatures and intra-seasonal drought (Jarvis et al.2012). However, if a prolonged drought period (>2 months) falls during the root thickening initiation state, a root yield reduction of up to 60% may occur (Jarvis et al., 2012). Cassava shows better yield gain than grain crops at higher CO2 concentrations, can recover from very long drought periods, and exhibits increases in optimum growth temperature under elevated CO2 levels (Rosenthal and Ort, 2012). Studies have indicated that cassava production will be more vulnerable to pests and diseases under climate change, thus hindering its productivity. Cassava brown streak virus disease (CBSD) has been identified as a major threat to cultivation worldwide. The whitefly is a pest of cassava and transmitter of pathogens. High temperatures lead to high fecundity, rapid development, and greater longevity of this insect; thus its spread.

(g) *Sweet potato:* Climate change will not only lead to the shift in areas suitable for potato production but also lead to reduced yields and poorer quality of tubers for processing while demand for potato irrigation is also expected to increase in the country. Distribution of pests (e.g. aphids, potato tuber moth and leaf miners) and diseases (e.g. late blight, bacterial wilt and viruses) are expected to increase since high temperatures allow more cycles of multiplication leading to greater pressure of pests and diseases. Sweet potato produced under high vector pressure may degenerate fast due to viral infection (Muthoni *et al.,* 2017).

(h) *Banana:* Major banana growing areas in Kenya include Kisii Region (AATF, 2009). Optimal banana production require a constant and ample supply of water due to its permanent green vegetation and shallow root system (Robinson, 1996). Though banana can survive water stress for long periods of time, low soil moisture and extended exposure to extreme temperatures (above 35°C) can reduce banana production (Thornton and Cramer, 2012). As such, in the Kenya highlands, where annual rainfall is below 1100 mm, drought-induced yield reduction on rainfed bananas can reach up to 65% compared to wetter areas (Van Asten et al., 2011). Also, variability in rainfall is expected to result in a loss of suitable banana cultivation areas in the lowlands (Ramirez et al., 2011). Though higher temperatures may increase suitable areas, rises in temperature also result in increased water demand, limiting banana cultivation to the areas projected to receive increased rainfall (Thornton, 2012). Meanwhile, highland bananas are projected to observe significant yield loss due to increased risk of pest and diseases especially if the temperature increases by 2°C (Thornton and Cramer, 2012).

Cash crops

(a) *Coffee*: Arabica coffee variety is predominantly grown in Kenya. Optimum growing temperature for Arabica is 18–23°C (International Coffee organization (ICO), 2009). Higher temperature hastens development and ripening of the cherry, impacting both productivity and quality of coffee. Based on a study by the International Coffee Organization (ICO, 2009), in Kenya, the optimal coffee producing zone is predicted to move upward from 1600 m to 1700 meter above sea level by 2050 (GIZ, 2010). The report also projected a decrease in suitable coffee producing area in the country from the current 50 – 70% to 30 – 50%. Further studies predicted shrinkage in coffee growing areas in most of Kenya, due to the prevalence of the coffee berry borer caused by increases in temperature by 2050 under A2 and B2 storylines (Jaramillo et al., 2011).

(b) *Tea:* Tea production is greatly influenced by seasonal fluctuations in climatic variables such as rainfall, temperature, solar radiation and humidity. Deviation from the favorable conditions characterized by increased temperatures and reduced moisture levels lead to osmotic stress that induce biochemical and physiological responses in tea, and as a result, tea quality and quantity is adversely affected (Cheserek, 2015). Increased temperatures can cause sun scorch damage and reduce water content in tea, consequently, lowering the tea quality and quantity produced. Similarly, low air temperatures in high altitudes, can potentially cause a drop in growth rate and reduced yields. Changing rainfall patterns create uncertainty on the appropriate time to apply fertilizers while extreme weather events such as droughts, floods, hailstorms, frosts and landslides cause crop damage and failure (Cheserek, 2015). The projected increase in rainfall and temperature variability in the country will render some tea growing zones in the country less suitable. The suitability of these areas is expected to drop by around 40% by 2050. The current optimum tea production zone (1500–2100m above sea level) will also shift to higher altitudes (2000–2300m above sea level) by 2050 (CIAT, 2011). Further studies project that a rise in temperature by 2°C would render large areas in Kenya currently suitable for tea production unsuitable (Simms, 2005).

(c) Sugarcane: About 85% of sugarcane production in the country is by smallholders (KSB, 2009; Assefa et al., 2010). Sugarcane is extensively grown in the Lake Victoria basin of Kenya and is considered the most important cash crop in the region (Netondo et al. 2010). Sugarcane requires a temperature of 30–32°C during the main growing season, while temperature above 35°C is detrimental to plant growth (Blackburn, 1984; Hunsgi, 1993). Additionally, a 2 – 3°C increase in temperature was reported have a positive impact on sucrose yield, while decreases in rainfall had a negative impact on sucrose yield (Kiker, 2002). It is therefore clear that climate change and variability is expected to continue influencing the quality and quantity of sugarcane production. This is especially in Kenya and other developing countries due to low adaptive capacity, high vulnerability to natural hazards, and poor forecasting systems and mitigating strategies (Zhao and Li, 2015).

Livestock sub-sector

Most livestock in Kenya are found in the ASAL areas, which occupy about 80% on the country's landmass. In these expansive rangelands of Kenya, livestock are dominantly kept in pastoral and agro-pastoral areas, and are mainly dependent on natural feed resources and water (Figure 3.3). The rangelands are climate sensitive, and therefore their productivity are highly affected by droughts floods and other effects of climate change. Increasing temperatures associated with corresponding reductions in precipitation and increased evaporation have been established to trigger drought and desertification in the rangeland. The resultant moisture deficits, leads to decimate forage availability and quality.

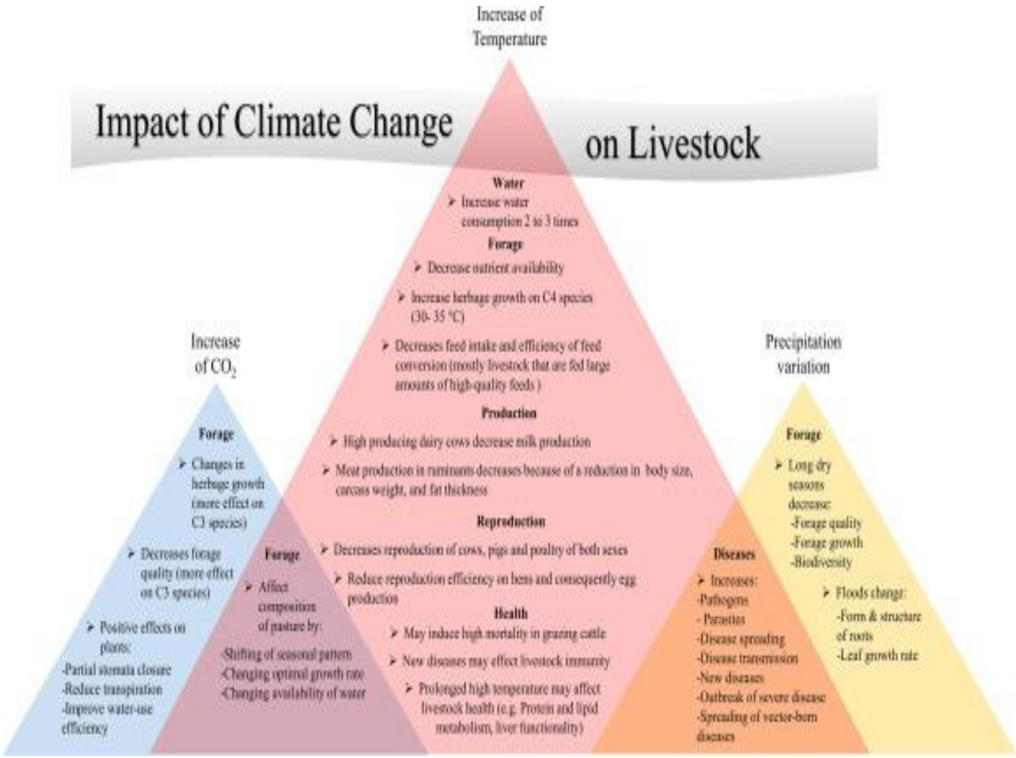


Figure 3.3. Impacts of climate change on livestock.

Source: Rojas-Downing et al., 2017

Climate change is influencing pastoral mobility trends, resulting from extensive droughts in different parts of the country which result progressive decline in vegetation quantity and quality, and inadequacy of water (Mussa *et al.,* 2016). For example, between 2008 and 2011 livestock was most affected by the drought, leading to a loss worth KShs 699 billion (ILRI, 2018). The former Rift Valley Province was the most affected region and 2009 was the year with the highest impact. Figure 3.4 shows the value of damages due to livestock deaths. The losses had significant influence on the food security status of the country and affected households. Climate change also exacerbates proliferation and spread of alien species in the environment, with increased chances of causing rangeland deterioration (Bolo et al., 2019).

Livestock's vulnerability to climate shocks depends on their exposure, which is determined by the duration, frequency and severity of the shocks, and the location of the stocks and related assets (e.g. feedstock, housing, water points). It also depends on their sensitivity, which is determined by the breed, the housing or feeding system, status of animal health (e.g. vaccination rate) and the importance of livestock to the household in terms of food security and livelihoods (ICEM, 2013). Some of the vector-borne diseases that are strongly associated with vector amplification due to climate variability include Rift Valley fever (RVF), West Nile Virus (WNV), Bluetongue (BTV) and Trypanosomosis. For instance, RVF in East Africa is strongly associated with extreme events, such as heavy rains and floods, caused by the El Niño Southern Oscillation events, which are expected to occur more frequently in the future as an effect of global climate change (FAO *et al.*, 2015).

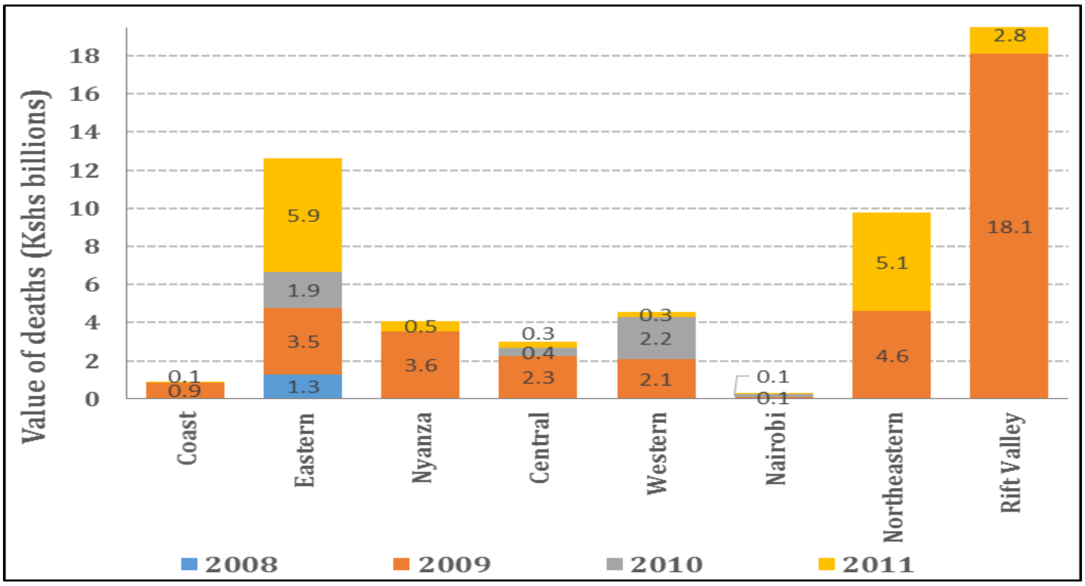


Figure 3.4. Value of livestock deaths (KES, millions).

Source: ATLAS, 2016

Fisheries sub-sector

Fisheries are affected by temperature changes in the aquatic environment in terms of breeding and feeding behaviour of the fish and have a significant effect on the species composition. The fish species are thinning and there's an abundance biomass owing to the effects of temperature increase on the nesting and breeding grounds (Maina, Newsham and Okoti, 2013). Also, increase in temperature affects nesting and feeding grounds leading to thinning of species and biomass abundance. For example, the total value of the effect of the drought on fisheries was estimated at KES 4.2 billion, comprising KES 3.6 billion in losses and KES 0.5 billion in damages (NCCRS, 2010).

Physical climate change impacts in oceans, lakes and rivers include changes to:

Heat content and temperature

Salinity, density and stratification Ocean circulation and coastal

Upwelling sea, lake and river levels

Sedimentation brought about by climate-induced changes to land use ocean acidification, and

Low frequency climate variability patterns (e.g. El Niño Southern Oscillation (ENSO)

Implication of fish and aquatic life

Physiological, spawning and recruitment processes of fish production (e.g. diatoms and phytoplankton)

Secondary production (e.g. zooplankton) distributions of fish (through permanent movement, or changes to migration patterns) the abundance of fish (due to changes in primary and secondary production) phenology (e.g. timing of life-cycle events such as spawning), and

Increased risk of alien invasive species and diseases

Implication to the local and national economies

Individual level: impacts on the incomes, assets, and livelihoods of individual fishers, fish farmers, processors, and those engaged in marketing and the provision of inputs to the sector;

National level: impacts on revenues, exports, per capita fish supply and contributions to employment and GDP.

Box 1: Impacts of climate change on fishery resources

Landscape and agroforestry

Landscape

Kenya is endowed with a variety of habitat and ecological systems including wildlife, forests, lakes and river, wetlands, farmlands, vegetation, marine life and other forms of micro-organisms. This rich biological diversity is however, experience substantial degradation and systemic alteration and shifts which result and are exacerbated by climate change and variability. The Kenyan landscapes though diverse and widely rich has become highly vulnerable to climate change effects.

(a) *Forests:* The forestry sector is vulnerable to climate change affecting species composition, growth rates and the regeneration capacity (Murphy *et al.,* 2012). According to KCCRS (2010), impacts of climate change in forestry include: i) direct climate change impacts on forest biodiversity and ecosystem services are likely to include: changes in phenol – or plant and animal lifecycles which may lead to loss of synchrony between species; changes in species abundance and distribution (including emergence of invasive species or loss of species through extinction); changes in the composition of plant and animal communities; and changes in ecosystem processes; and ii) indirectly it impact forest biodiversity and ecosystem services through changes in socio - economic drivers, working practices, cultural values, policies and use of land and other resources (KEFRI, 2018). Other impacts of climate change include increased exposure to fire, pathogens and invasive species and educed provision of environmental resources and economic activity. Forest ecosystems also enhance landscape resilience to climate change through provision of environmental services such as water quality and quantity, reduction of soil erosion, and creation of micro-climatic conditions that improves productivity and acts as carbon sinks for the greenhouse gases. Kenya is committed to restoring 5.1 million hectares of degraded and deforested landscapes by 2030 as its contribution to the African Forest and Landscape Restoration Initiative (AFR100), a pan-African, country - led effort to restore 100 million hectares of deforested and degraded landscapes (KEFRI, 2018).

(b) Rangelands/woodlands: Kenyan rangelands cover nearly 70% of the country (figure 1) and are a home for millions of pastoralists and agro-pastoralists practicing agriculture mainly livestock keeping at small scale level. Rangelands in Kenya are characterized by a number of habitat structures ranging from open grasslands to closed woody or bushy vegetation with varying amounts and composition of grass cover and grass species respectively. The composition of grass species and the abundance of cover are dependent on a number of ecological conditions including; thermal regimes, rainfall amounts and duration of wet versus dry seasons, soil moisture content, and the phenology of the shrub and tree canopies in the area they grow (Tieszen *et al.,* 1979). These ecological conditions are known to influence the type of species present in an area to one of two adaptations on photosynthesis commonly referred to as C3 and C4 photosynthetic pathways (Tieszen *et al.,* 1979). Cooler, wetter and more shaded habitats tend to favour the C3 grass species commonly referred to as tall grasses, while the warmer, drier and more open habitats tend to favour the C4 species commonly known as short grass species (Izaurralde *et al.,* 2011). A change in the environmental conditions described above

will alter both the abundance and composition of grass species either to more of the short grasses or more of the tall grasses and vice versa depending on the way the environment changes. Where these alterations take place, there are serious impacts on grazing regimes as they may reduce or increase the preferred habitats for different herds. The change may also alter the amount of palatable or non-palatable grass species, presence of short grass species for grazers, and as well as the suitability of habitats for grazers and browsers.

The impacts on grazing systems include changes in herbage growth (brought about by changes in atmospheric CO2 concentrations and rainfall and temperature regimes) and changes in the composition of pastures and in herbage quality. In higher latitudes, future increases in precipitation may not compensate for the declines in forage quality that accompany projected temperature increases, and cattle will experience greater nutritional stress in the future (Crane *et al.,* 2010).

Increases in CO2 concentrations and precipitation will tend to increase rangeland net primary production, though this increase in production will be modified, positively or negatively by increased temperatures. At least to the 2050s, increases in CO2 will benefit C3 pasture species, although warmer temperatures and drier conditions will tend to favour C4 pasture species (Herrero *et al.,* 2016). The proportion of browse in rangelands may increase in combination with more competition if dry spells are more frequent (1). In a future East Africa with a warmer, wetter climate, for example, C4 grass productivity may decrease, while tropical broadleaf growth may increase. In such regions, decreasing grass cover would likely result in more competition for forage amongst grazing species ((Izaurralde *et al.,* 2011). Changes in net primary productivity in African and Australian rangelands are likely to be largely negative (Herrero *et al.,* 2016). Projections into the future generally indicate widespread negative impacts on forage quality.

The semi-arid and arid rangelands are likely to see increasing rainfall variability, with associated impacts on rangeland productivity. This may have significant negative effects on herd dynamics, stocking density and the productivity of pastoral production systems. In arid and semi-arid Kenya, for example, the loss of animals and subsequent losses in milk and meat production to 2030 as a result of increased drought frequency could amount to more than US $630 million (Thornton *et al.,* 2014). Changing frequencies of extreme weather events such as flooding will affect certain diseases too: for example, outbreaks of Rift Valley fever in East Africa are associated with increased rainfall and flooding due to El Niño–Southern Oscillation events (Herrero *et al.,* 2016).

(c) Wetlands: Wetlands serve a broad range of functions. They play an important role as filters for pollutants arising from their catchment. They provide ecosystem services such as water, papyrus products, fisheries, and recreation. Local communities rely on wetlands for products including firewood, thatch grass and fodder for their livestock. They are very important carbon sinks that contribute to global climate regulation (KWS, 2013). These functions have a key contribution in achievement of the government's Big Four agenda especially on promoting expansion of the manufacturing sector, affordable housing and achieving food security. Thus, wetlands play a critical role in enabling communities to mitigate and build resilience against the impacts of climate change. At the same time, wetlands are fragile ecosystems which are highly vulnerable to the effects of climate change.

Wetland ecosystems can be severely impacted or even destroyed by drought, but also provide water storage and often groundwater recharge capacity which can contribute to drought management. When changing rain patterns bring heavy rainfall, wetlands may be negatively impacted by increase in contaminated runoff but can also provide flood storage and filter at least some pollutants from runoff reaching other waters. Wetland habitat can be altered by hydrological changes. Their biodiversity richness may shift following temperature alterations, but they can also provide migration pathways and refuge for some species (Nature Kenya, 2019).

Wetlands sequester significant amounts of carbon as compared to other ecosystems. For example, the ecosystem services assessment for the *Yala* Swamp conducted in 2015 indicated that soil and vegetation carbon pools were greatest in natural and semi-natural papyrus-dominated habitats and lowest in the drained farmed areas.

The extreme climate events such as drought and disease (both human and animal) are priority risks impacting on crops, livestock, fisheries, and human health. For example, in the Mara Wetland of Kenya, deforestation and overgrazing driven by rapidly growing population, cooking fuel sources and inappropriate livestock production methods. Almost 98% of the population uses firewood or charcoal as a primary fuel source for cooking, and many often turn to illegal logging and charcoal making during periods of crop loss (KNBS, 2016). During the 2017 drought that caused widespread crop failures, the North Mara WUA estimated that 70% of the community turned to illegal forest harvesting. Approximately 95% of ruminant livestock in the region are kept under traditional production systems, which depend on grazing and crop residues as the main feed source (Nile Basin Initiative, 2008; CGIAR, 2016). Overgrazing and clearing forested land for pasture increase soil erosion, particularly in areas with steep slopes such as those found in Tarime District. This clearing makes the area more susceptible to landslides, flooding, river siltation and soil nutrient loss, all of which will be exacerbated by climate variability and change.

The adaptation options to manage the impacts of climate variability and climate change on wetlands include:

- Promoting agroforestry to address soil erosion and land degradation, including providing key inputs, materials, training, and extension to enable on-farm agroforestry.
- Promoting sustainable production and management of livestock, including formulation and enforcement of by-laws regulating entry of livestock into ecologically sensitive areas, as well as support to farmers to access improved livestock breeds, employ reduced-impact feeding techniques, and benefit from new market opportunities.
- Establishing domestic water supply schemes, including formulating plans for enhancement of water supply and storage facilities at village and household

levels, implementing water supply and storage upgrades, and establishing maintenance arrangements with local WUAs.

- Controlling soil erosion, including rehabilitating soils, implementing terracing along catchment slopes, and training extension workers on soil management technologies and techniques.
- Promoting the best climate change adaptation technologies in the wetland ecosystems, including climate-smart agriculture and improved cookstoves.
- Promoting ecosystem restoration and sustainable land management through tree-based business measures such as on-farm tree planting, community and institutional woodlots, and development of associated income-generating and value-adding opportunities (e.g., nurseries and seedling production, small-scale wood processing, and fruit and fodder production)
- Regulating water abstraction, including conducting an environmental flow assessment for the wetlands and using the results to develop abstraction regulations.
- Collating and improving data for the wetlands and adjacent areas, including regular biodiversity, social and demographic, and water level, quality and quantity surveys, along with repairing existing data stations and restarting regular data collection.

Agroforestry

A typical agroforestry system consists of various components: trees, agricultural crops, pastures, livestock and soils, trees being present at all agroforestry systems and practices (Young, 1997). There are three basic sets of elements or components namely the tree or w perennials, the agricultural element and the animal. Tree cover on farms has the potential to make an important contribution to climate change mitigation. There are many benefits of incorporating the planting of trees in farm management such as improve carbon sequestration; reduce soil erosion; improve soil management; attract vital pollinators and birds, improve water management; shelter and shade for livestock and crops, lessen the risk of salinisation and a source of natural remedies. The three agroforestry systems in Kenya include:

- Agrosilviculture: In this system selected tree species are integrated in c production systems. Examples include, among others, *Taungya* or Sha system, trees on cropland and boundary planting.
- Silvopastoral: This entails integration of trees in livestock production system Examples include most systems of trees in pastures and apiculture involves use of trees to raise bees for honey.
- Agrosilvipastoral entails integration of crops, trees and pasture or annuals' one system. Examples are woody perennials on cropland for fodder, green manure, home gardens including a number of woody plants that are grown with crops and provide fodder for livestock.

Agroforestry is an often named solution for the dual climate and food security challenges (Dinesh *et al.,* 2017). Agroforestry practices, such as the integration of leguminous trees into fallow periods between two cropping seasons (improved fallow), or intercropping short - and long - term trees with crops (dispersed intercropping), can lead to higher crop yields in many parts of the tropics (Hall et al. 2005), and increased well - being (Thorlakson and Neufeldt, 2012; Reppin, *et al.,* 2020).

Also, agroforestry can mitigate climate change through creating and enhancing carbon sinks by capturing carbon from the atmosphere through photosynthesis and storing it in biomass and soil (Albrecht and Kandji, 2003). Considering only the tree component of agroforestry systems, estimates based on growth rates and wood production from a limited number of studies show an average carbon stock in agroforestry systems between 9 and 63 Mg C ha/ year depending on the climate (semi-arid to temperate) (Montagnini and Nair, 2004). However, carbon stocks in agroforestry systems of the tropics vary even for similar types of agroforestry systems (Nair and Nair, 2014) due to the diversity of agroforestry practices (e.g., home gardens, windbreaks, intercropping, woodlots, etc.) and the impact of environmental (e.g., access to soil moisture, light and nutrients) and management (e.g., pruning and felling) factors suggesting the potential for agroforestry to be a low emission development strategy may be site specific.

Agroforestry is a widespread practice in developing countries including Kenya and developed countries, and its visibility is increasing at national level and in international institutions. However, there are a number of barriers working at different scales that are preventing a broad-scale implementation of agroforestry practices, such as inefficient markets, unclear land-rights, limited access to knowledge and finance and lack of intersectoral collaboration (Agroforestry Network, 2018). The Agroforestry Network proposes key enabling actions to scaling-up agroforestry (2018), which include:

- Improving access to credit and monetary resources, e.g. by supporting scalable financial models addressing long-term returns on investment in agroforestry practices.
- Improving farmers' access to markets and creating value chains for agroforestry products.
- Improving farmers' access to high-quality planting material and extension services.
- Improving demand driven, participatory and inclusive agroforestry-related research. Despite intentions to expand agroforestry practices, significant gaps exist between countries' ambitions and their capabilities to measure, report and verify agroforestry actions (Rosenstock *et al.,* 2018). There is a need to develop strategies, frameworks and indicators at all levels to measure agroforestry diversified systems and climate benefits

In Kenya just as is in most parts of Africa, climate change mitigation focuses on reforestation and forest protection. But such efforts to reduce tropical deforestation (often under REDD) conflict with the need to expand agricultural production in African countries to feed the continent's growing population Agroforestry could be a win-win solution to the seemingly difficult choice between reforestation and agricultural land use, because it increases the storage of carbon and may also enhance agricultural productivity.

Productive resources

Land resources

Climate change alters the balance of environments, creating new conditions or increasing variability that in turn can affect the economic value, cultural use or physical condition of land. Unsustainable land use practices may lead to accelerating land degradation or productivity loss. Insecure ownership created by conflicting laws and insufficient information leave the homes and livelihoods of many Kenyans at risk, especially as climate change further destabilises land ownership and management. Such insecurity hampers economic development by discouraging household investment and increasing internal migration (NAP, 2017). Examples of ongoing projects/initiatives Preparation of Land Use Policy, National Spatial Plan concept, Revision of Kenya National Atlas, Development of Community Land Bill, County Spatial Plans. Some of the initiatives to enhance the resilience of the land resources include: building the capacity of land planners in climate change land-use planning; integrating climate change scenarios into spatial planning, building the capacity of land managers in climate change adaptation and updating of land-use plans with climate scenarios.

Soils

Kenya is a country with varying climate, vegetation, topography and underlying parent rock. Climate is the most important factor influencing soil formation and affects soil type directly through its weathering effects and indirectly as a result of its influence on vegetation. In most parts of Kenya, soils are deficient in nitrogen, phosphorous and occasionally potassium. In dry areas, the soils have low organic matter mainly because rainfall is low, variable, unreliable and poorly distributed. To understand the distribution of soil in Kenya, the country can be divided into three broad regions: humid, sub-humid and arid. The humid regions (highlands) are areas with an altitude of over 1500m which receive an annual rainfall of over 1000 mm, and include the highlands east and west of the Rift Valley and the Rift Valley floor. They have volcanic rocks and the soils are mainly loamy. Other humid areas with an altitude less than 1500m (humid lowlands) have sandy soils which are well drained and are of loamy, sandy clay texture (e.g. along the Kenyan coast). Other areas of the highlands have fertile loam soils, while alluvial soils (silts) are found along river valleys. Sand dunes and mangrove swamps are found along the coast. The soils covered by mangrove swamps are deep, grey, saline and poorly drained. The sub-humid regions (the Lake Region and western Kenya) receive slightly less rainfall than the humid areas. They have volcanic and basement rocks and soils are red clay and generally productive. These regions lie between 1000m and 2000m above sea level and rainfall is up to 1000 mm per year. Dark red clays, sandy loams and alluvial deposits of eroded material from the uplands are common along the flood plains of big rivers in these regions. Peat swampy soils and black cotton soils dominate the lowlands. The semi-arid regions (northern and northeastern Kenya) receive on average 300–500 mm of rainfall per year and their soils are shallow and generally infertile, but variable. These soils have developed mainly from sedimentary rocks. Fertile volcanic soils, black cotton soils, dark red 8 soils, lava soils and alluvial soils are scattered across the region depending on the distribution of rainfall, altitude and parent rock type (Kabubo and Karanja 2007).

Climate change is threatening food security nationally and are more vulnerable in view of the tropical climate and poor coping capacity of the small and marginal farmers. Climate change is projected to have significant impacts on agriculture through direct and indirect effects on crops, soils, livestock and pests (Kabubo *et al.,* 2007). Though, climate change is a slow process involving relatively small changes in temperature and precipitation over long period of time, nevertheless these slow changes in climate influence the various soil processes particularly those related to soil fertility. The effects of climate change on soils are expected mainly through alteration in soil moisture conditions and increase in soil temperature and CO_2 levels as a result of climate change. The global climate change is projected to have variable effects on soil processes and properties important for restoring soil fertility and productivity. The major effect of climate change is expected through elevation in CO_2 and increase in temperature.

Soil formation is controlled by numerous factors including climatic factors such as temperature and precipitation. These parameters of climate influence the soil formation directly by providing biomass and conditions for weathering. Main parameters of climate that directly influence on soil formation are sum of active temperatures and precipitation-evaporation ratio. They determine values of energy consumption for soil formation and water balances in soil, mechanism of organic-mineral interactions, transformation of organic and mineral substances and flows of soil solutions. Changes in external factors of soil formation (temperatures and precipitation) will lead to transformation of internal factors (energy, hydrological, biological). The climate change will increase energy of destruction of soil minerals resulting in simplification of mineral matrix due to accumulation of minerals tolerant to weathering. It will lead loss of soil function for fertility maintenance and greater dependence of on minerals.

Climate change will influence soil moisture levels by direct climatic effects (precipitation, temperature effects on evaporation), climate induced changes in vegetation, plant growth rates, rates of soil water extraction by plants and the effect of enhanced CO_2vlevels on plant transpiration. Changes in soil water fluxes may also feed back to the climate itself and even may contribute to drought conditions by decreasing available moisture, altering circulation patterns and increasing air temperatures. Among various factors controlling the process of soil development, climate plays a major role in weathering of rocks and minerals. The variables of climate change particularly temperature and rainfall dictates various stages of weathering of rocks and minerals (parent material) resulting in chemical and mineralogical changes in soil forming rocks. Water is very essential for chemical weathering to take place and hence, an increase in rainfall accelerates weathering. The same types of primary minerals give rise to different secondary minerals when the conditions of weathering differ. Thus similar rock types undergoing weathering in different climatic conditions could give rise to distinct soil profiles. (Kabubo *et al.,* 2007).

The drivers of climate change such as moisture, temperature and CO_2 are expected to have variable effects on various soil processes and properties having relevance in soil fertility and productivity. However, these effects of the climate change factors cannot be viewed separately, being one factor influence the other and resultant effect would be complex. Further, all these effects will be highly region specific, depending on the magnitude of the climate change, soil properties and climatic conditions. The adaptation strategies in agroforestry include; conservation agriculture technologies (minimum soil disturbance, cover crops and crop rotations including legumes), soil conservation measures (e.g. contour farming) and nutrient replenishment strategies can restore soil organic matter by providing a protective soil cover and an environment conducive to vigorous plant growth (Kabubo *et al.,* 2007; NCCAP, 2018).

Water resources

Kenya is a water scarce country. The natural endowment of renewable freshwater is low and water resources are unevenly distributed in both time and space. Climate change will worsen this already precarious situation as it affects the main hydrological components: (i) precipitation and (ii) run off. This will alter the spatial and temporal availability of water resources (Mueni, 2016; Mach & Mastrandrea, 2014). The rise in temperature leads to an increase of the water vapour content in the atmosphere, a change in the regime and intensity of precipitation, an increase in evaporation from the earth's surface, a decrease in snow cover. The impacts of climate change on water resources, in turn, affect all major sectors of the economy. Changes in precipitation patterns due to climatic factors also affect soil moisture. Insufficient replenishment and increased evaporation in the long term absence of precipitation cause the prolonged droughts that threaten water and food security. Thus, climate change affects spatial and temporal variability in water availability, creating new and exacerbating current water security.

Adaptation measures being undertaken

Agricultural adaptation measures to climate change occur at various spatial and temporal scales. The government of Kenya has supported several projects and program to build the resilience of the agriculture sector in the country. The various adaptation programs are aimed at reducing vulnerability to climatic stresses, such as drought events and climate variability. Table 3.1 below provides overall focus areas of various past and ongoing climate adaptation programs and projects in the country.

Table 3.1. Classification and description of adaptation measures to climate change.

Category	Adaptation measures	Key components of agriculture programs for climate adaptation
Farm production	Change to drought-resistant variety Change to early-maturing variety	Development and use of stress-tolerant crop varieties to improve yields and agricultural productivity in light of drought. For instance, in the case of maize, different varieties have been developed for farmers to choose based on their areas: there are drought-resistant and early-maturing varieties
	Artificial fertilizer Animal manure	Promoting the use and appropriate application of mineral fertilizer and animal manure to increase yields and improve soil fertility with positive consequences for climate change resilience
	Agro-chemicals (Pesticides/Herbicides/ Fungicides)	Promoting the use of agro-chemicals as an effective way for pest control in the crop farms
	Improved/drought-resistant livestock breed Change livestock feed management	Supporting communities/farmers to switch to livestock that are more tolerant to drought or diseases for improved productivity and drought resilience in the livestock sector. Especially, local breeds are already adapted to harsh climate conditions. Promoting livestock feed management towards improved by pasture reseeding, conservation, storing animal feeds, e.g. as napier grass,
Land use	Mixed cropping and inter-cropping	Enhancing planting of two or more crops simultaneously in the same field to increase soil biodiversity and fertility, help to conserve water and increases returns per hectare. Spreading the risk on different crops on one plot is a typical trait of smallholder farming systems to cope with climate variability and has been supported and practiced over the years.
	Crop rotation	Enhancing crop rotation thereby promoting soil fertility and reducing sensitivity to pests and diseases.
	Agroforestry	Supporting planting of woody species among or in proximity to the main crops, fruit, fodder and fuel wood production can be increased, while runoff or erosion is decreased and soil fertility is enhanced. Trees provide shade, shelter and protection from wind. Agroforestry has the potential to increase farmer's resilience to climate change
	Conservation tillage (mulch-tillage (leaving crop residues on the field), reduced or zero tillage)	Enhancing conservation farming to improve on-farm water productivity, increase yields and increase farmers' ability to deal with increased climate variability
Topography	In-field water conservation (terraces, furrows, trenches, windbreaks)	Building terraces and bunds or changing the slope of the field to slow the speed of water and increases thus infiltration close to the crops' roots to improve irrigation efficiency.
	Water-harvesting and storage (dams/reservoirs/ ponds)	Promoting farm level water harvesting using structures like ridges, bunds and dams, rainwater is diverted, stored and used for irrigation at a later point in time. Harvested water is used for supplemental irrigation during dry spells to increase yield stability or for planting off-season cash crops to increase

		household income.
Water management	Introducing/Improving irrigation system Water resource exploitation (boreholes/wells/ water pumps to access river water)	Supporting irrigation to improve farm productivity, enable diversification of production (e.g. to horticultural products) by increasing moisture retention in the soil and increasing water availability.
Timing	Early/late planting	Enhancing early/late planting to maximize farm productivity during the growing season and reduce heat stress and moisture deficiencies. Late planting minimizes the risk of being surprised by a late onset of the rains. Early planting is practiced in order to enable replanting in case the crops do not germinate.

Adaptation co-benefits and mitigation potential of the agriculture sector

Overview

Mitigation and adaptation are both essential aspects of dealing with climate change, but adaptation becomes costlier and less effective as the magnitude of climate change grows. Consequently, when mitigation objectives are affordably achieved, adaptation requirements are reduced and the ultimate result is less stress. The strategies for reducing emissions also have significant synergies with adaptation. Therefore, pursuing synergies between mitigation and adaptation in the context of increasing agricultural production and reducing poverty will be particularly important in building resilience to the effects of climate change.

Global technical mitigation potential in the agricultural sector is high – at between an estimated 5.5 and 6.0 gigatons (Gt) of CO_2eq/yr by 2030. The majority of these emission reductions can be achieved through effective changes in agricultural management practices that increase soil carbon, reduce methane emissions from flooded rice fields and improve nitrogen fertilizer usage. Agriculture is the main source of GHG emissions in Kenya. The sector contributes 62.8% of total emissions, excluding emissions from the land-use change and forestry (LUCF) sector. Other sectors are: waste management, industrial, energy, transport, electricity and forestry (Figure 4.1).

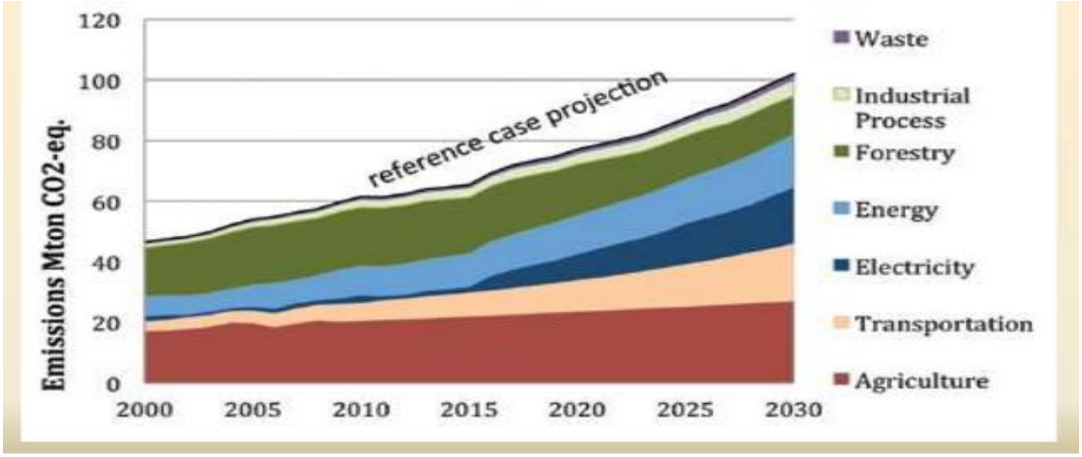


Figure 4.1. GHG Emissions projection (Kenya), 2010- 2030 and the available options for mitigation.

Within agriculture, 56% of emissions were due to enteric fermentation from livestock, and 38% due to manure left on pasture (WRI CAIT, 2017) (Figure 4.2). Other sources in small proportions are synthetic fertizers, rice production, and burning. It is estimated that 1990 to 2013, the number of cattle increased by 32%, sheep and goats doubled while camels increased threefold (FAO, 2014). As a consequence, agriculture emissions increased by 59% (WRI CAIT, 2017).

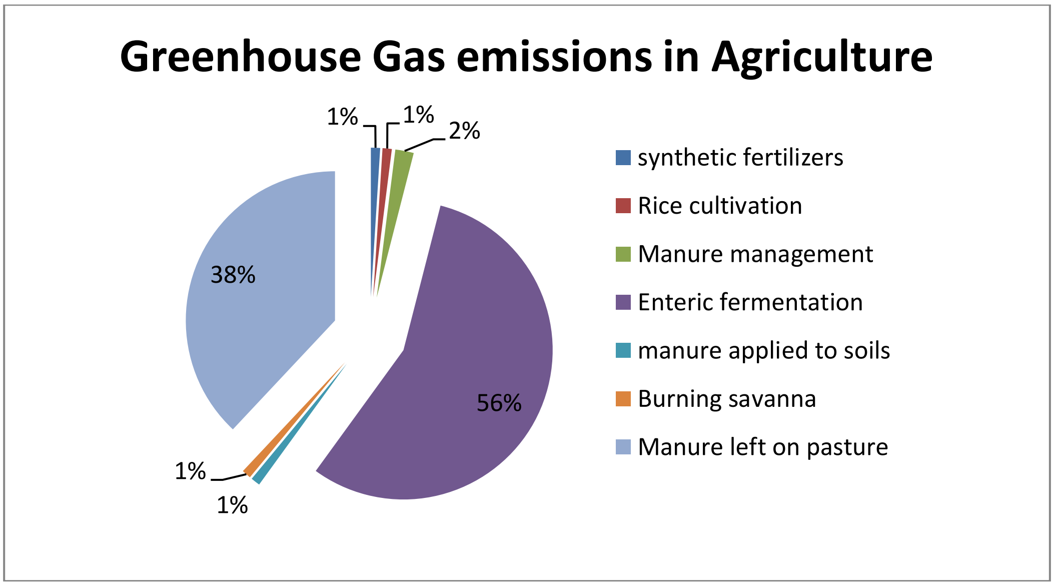


Figure 4.2. GHG emissions from the Agriculture sector in Kenya

(Source: FAOSTAT, 2014)

A number of mitigation options are available for the agriculture sector in Kenya such as: adoption of no till or reduced tillage; agroforestry; use of cover crops; use of crop residues for mulch; improved water management for irrigated crops; improved livestock breeds and feeds and manure management among others. Most of these options would not only have great potential for carbon sequestration but also promote a sustainable increase in productivity by increasing soil organic carbon.

Mitigation potential of the agriculture sub-sectors

Mitigation strategies in agriculture can be categorized in three ways: carbon sequestration into soils, on-farm emission reduction and emission displacements from the transportation sector through biofuels (Table 4.4). Sequestration activities that enhance and preserve carbon sinks include: any practices that store carbon through cropland subsector such as no till etc; many on-farm management practices; and production of biofuels.

Crop sub-sector

The crops sub-sector contributes about 10% of all emissions from the agriculture sector and the major greenhouse gases emitted are CO_2, CH_4 and N_2O. Poor agricultural practices such as inappropriate tillage, flooding of paddy rice fields, burning of agricultural residues, clearing of trees in farmlands and inappropriate use of fertilizers contribute to GHG emissions. For instance, approximately 2.3 million ha of crop residues from maize, wheat, sugarcane and rice are burned annually, leading to emissions of 0.93 $MtCO_2e$ per year. Other sources of emissions are from the use of agricultural machinery, post-harvest practices, agro-processing and residue management (MOALF, 2017). Agroforestry can play a critical role in the crop subsector as it can contribute to both sequestration and higher soil nutrients and water retention resulting in higher crop yields among other co-benefits.

The paddy rice production system is one of the major sources of emissions. Emissions from paddy rice depend on rice varieties, water management regime, soil organic matter management, temperature, soil properties, as well as rice straw management. The poor management of rice straw in flooded paddy rice production systems contributes to methane emissions. Application of rice straw to paddy fields significantly increases the methane emission rate compared to application of the rice straw compost or chemical fertilizer. The burning of rice residues such as straw and husks also contributes to GHG emissions.

There are various mitigation options (Table 4.1) that are available to support mitigation efforts for the agriculture sub-sectors. These include: appropriate use of chemical and inorganic fertilizers; use of improved crop varieties that allocate more biomass underground; rotations with legume crops that reduce the need for nitrogen fertilizer; use of crop residues for mulch; use of agroforestry; adoption of reduced tillage and use of improved crop residue management. Most of the agronomic practices contribute to building of soil organic matter inputs to soil thus increasing mitigation potential through increases in soil organic carbon stocks.

Table 4.1. The mitigation options and additional benefits in crop-sub-sector, Kenya.

Technology/Practice	GHG Objectives	Additional benefits
Sustainable land management e.g. conservation agriculture	Sequestration and emission reduction	It controls soil erosion control and promotes water conservation. It combats soil degradation resulting from agricultural practices that deplete the organic matter and nutrient content of the soil; thus improved crop yields and lower production costs.
Minimum tillage		No tillage or reduced intensity tillage are frequently proposed mitigation measures for preservation of SOC and improvement of soil quality, for example for reducing erosion. Whilst several reviews have demonstrated benefits to carbon conservation of no till agriculture over intensive tillage (Haddaway, *et al.,* 2016)
Improved crop varieties	Sequestration and emissions reduction	op varieties that are resistant to climate-related phenomena and more efficient in their use of resources to reduce their impact on the agricultural ecosystem and the wider environment. Resistance to drought, salinity and flooding are the most common climate-related traits for which crop varieties are bred
Crop diversity (rotation &cover crops)	Sequestration	When combined with conservation tillage, leads to higher soil-carbon content and also contributes to improved water and soil quality
Organic agriculture	Sequestration and emissions reduction	When combined with conservation tillage, leads to higher soil-carbon content and also contributes to improved water and soil quality
Mulching	Sequestration	Enhances the SOM and improve the soil's physical and chemical properties which help to sequester more C in soil which ultimately contributes towards Soil Organic Carbon storage, Carbon sequestration and Climate change mitigation

Livestock sub-sector

The livestock sub-sector contributes about 90% of the emissions from the agriculture sector and about 30% of the overall emissions at the national level. Livestock farming systems are largely extensive grazing. The pastures are generally of low quality and low digestibility coupled with poor animal husbandry, accounts for the high methane and nitrous oxide emissions. The livestock emissions are mainly associated with enteric fermentation and manure management. Overstocking is a common feature in pastoral and agro-pastoral areas that harbor the largest herd of livestock. The consequence of overstocking is overgrazing and land degradation coupled with burning of pasture in rangelands has a net effect on sequestration and release of GHG emissions. The use of fire for rangeland management is a common practice in Kenya, with over 430,000 hectares burned each year leading to a release of approximately 0.26 Mt of CO_2e per year emissions.

A number of mitigation options are available in the livestock sub-sector. These include: Improving forage quality for animal feed has the potential to reduce emissions intensity by 8-24% on intensive and semi-intensive dairy farms (Ericksen and Crane 2018); and Proper storage and covering manure heaps has the potential of reducing methane emission by up to 90% from manure among others.

Table 4.2. The mitigation options and additional benefits in Livestock sub-sector, Kenya

Technology/Practice	GHG Objectives	Additional benefits
Manure management	Emission reduction	Source of biogas fuel and the electricity resulting from large operations; and also provide nutrients to crops
Rotational grazing and improved feedstock	Sequestration and emissions reduction	Reduces water requirements, tolerant to droughts and fertilizes the grazing fields
Feed management	Emission reduction	Promotes more efficient use of livestock feed, improves water quality and energy efficiency and reduces the quantity of nutrients and cost of production
Limiting use of fire in range and crop and management	Emission reduction	It protects the soils against the micro-organisms that are critical for the decomposition and mineralization process. Also, the range plants and crops act as carbon sinks through the process of photosynthesis
Livestock substitution	Emission reduction	Intergovernmental panel on climate change (IPCC) reports that emission factors determine that camels have greater methane emissions through enteric fermentation than cattle.
Reduction in the size of cattle herds	Emission reduction	This reduces the overgrazing and the exposure of the soil carbon to degradation through erosion etc.

Reduced emissions from rice production	Sequestration and Emission reduction	Emissions from rice production systems can be reduced through the promotion of rain-fed rice, and the development and promotion of programmes and technologies for efficient rice production.

Fisheries and aquaculture sub-sector

In capture fisheries, a number of activities contribute to GHG emissions either directly or in-directly. These include the use of fossil fuel and inefficient engines; long fishing hours, transportation, and storage and processing of fish. Fishing on depleted fish stocks requires more fuel per kilogram of landed fish than fishing on abundant fish stocks, because low fish abundance forces fishers to search longer and use of heavier gear to catch the fish. A number of mitigation options could be pursued. The options are discussed in Table 4.3 below.

Table 4.3. The mitigation options and additional benefits in Livestock sub-sector, Kenya

Technology/Practice	GHG Objective	Additional benefits
Reduction in fuel usage and emissions in fishing vessel engines	Emission reduction	Promote more efficient vessel design reducing engine size requirements to reduce on cost.
Promote fuel-efficient fishing methods	Emission reduction	Use of fuel-efficient fishing methods enhances efficiency
Use of static methods rather than active gear such as trawling, with its high energy requirements –	Emission reduction	Through differential licensing conditions and decommissioning support. The development of low-impact aquaculture, such as herbivorous aquaculture species, also has a role to play.
Improvements in building design and handling practices	Emission reduction	It reduces energy requirements and improve energy efficiency can make a great contribution. Examples include better insulation within cold plants and refrigerators used in the fishing operations and storage.
Fuel use for the further transportation of fish to markets can also be made more efficient.	Emissions reduction	It also reduces the cost of transportation
Protect and rehabilitate mangroves, as they have a valuable role to play in sequestering carbon.	Emission reduction and sequestratio n	Provides source of food and fuel wood to adjacent communities, reduce the rate of soil erosion
Livestock substitution	Emission	livestock substitution is taking place in

	reduction	Kenya and could be a mitigation option. For example, camels have greater value than cattle in Kenya and that a farmer could keep a few camels and substitution However, information was not available on the ratio of substitution of goats for cattle (for example, one for one, or three for one)
Reducing enteric methane emissions in sector.	Emission reduction	consistent with the Kenya Climate Smart Agriculture Strategy, 2016-2025, that prioritizes the reduction of emissions from livestock.22 A short-term action is to reduce emissions in the dairy
Reduction in the size of cattle herds	Emission reduction	A reduction in herd size leads to a reduction in feed requirement and coz of the green gas emissions
Manure Management	Emission reduction	improved manure management, treatment or storage remains key.

Source: Modified from NCCAP (2018)

Landscapes and agroforestry

Landscapes

Forests: The INDC states that Kenya's total greenhouse gas (GHG) emissions were around 73 million tCO2 e in 2010, of which 75% were from the land use, land-use change and forestry (LULUCF) and agriculture sectors (UN-REDD, 2017). The energy sector through efficiency improvements in charcoal production and fuelwood consumption remain the most promising option to reduce GHG emissions. They have the potential to reduce emissions by about 21 million tCO2e per year or around 27% of Kenya's total greenhouse gas emissions (against 2010 numbers). This would therefore go a long way to meeting Kenya's climate goals. Many Kenyans consume charcoal and about 2.5 million are involved in transport and marketing with another 700,000 charcoal producers. Thus, efficiency technologies are essential since they have the potential to reduce wood use to 3 to 6 kg of wood to produce 1 kg of charcoal; currently, 10 kg of wood is required to produce one kilogram of charcoal (UN REDD, 2018).

Woodlands/Rangelands: Kenya's GHG emissions in 2015 were estimated to be 30 million tons of carbon dioxide equivalent ($MtCO_2e$) and is projected to rise to 39 $MtCO_2e$ by 2030 unless appropriate mitigation actions are taken (GoK, 2017). The agriculture sector contributes approximately 41% of total anthropogenic GHG emissions (NEMA, 2015). Pastoralism is the dominant land use and the most important economic and livelihood activity in the 85% of Kenya's land area classified as arid and semi-arid (ASAL) (Amwata et al., 2015). At the same time, the livestock sub-sector is reported to contribute over 50% of Kenya's agricultural GHG emissions (NCAAP, 2018). The vastness of ASALs coupled with poor grazing management has exacerbated the contribution of the livestock sub-sector to the national GHG inventories.

Further, overgrazing, rapidly expanding population, urbanization have also contributed to the degradation of the rangeland resources including vegetation, soils etc. For example, degraded soils often have low GHG emission rates and restoration of these soils may increase the emission of GHGs. The increased GHG emissions from restored rangelands are thought to be related to the increased vegetation cover and biomass production, soil organic carbon (SOC) content, improved soil moisture content, and the reduced soil compaction (Oduor *et al.,* 2018). The effect of grazing on bio-chemical processes that influence GHG emissions may vary with the type of grazing management practice. For example, high concentrations of nutrients and microorganisms in vegetated sites may increase GHG emission compared to bare soil, with soil moisture strongly regulating the fluxes (Oduor *et al.,* 2018). For example, Dabasso *et al.,* 2014 and Svanlund (2014) have reported the initial SOC tonnes of carbon /ha) for Kenyan grasslands to range between 0 to 77.8 to 92.90 , however, the SOC sequestration rate (tonnes carbon/ha/year) is not yet known.

Wetlands: In Kenya, six wetland areas have been designated by Ramsar for international importance due to the significant habitats encompassed by the wetlands. These include Tana River Delta; Lake Nakuru; Lake Naivasha; Lake Elementaita; Lake Bogoria and Lake Baringo. Wetlands are both GHG sources (notably methane) and sinks (notably carbon dioxide) (MEMR, 2012). Wetlands store large amounts of carbon and when these wetlands are lost or degraded, CO2 and other greenhouse gases are released into the atmosphere in large quantities. Therefore, conserving wetlands is a viable way of maintaining existing carbon stores and avoiding CO2 and other emissions. For instance, wetlands are estimated to cover 3% of the world's land surface, and are reported to be the largest carbon store, with about 550 gigatonnes of carbon worldwide. UNEP informs us that managing and maintaining the value of wetlands is quick and cost-effective. It reduces as much as 10% of greenhouse emissions (IPCC 1996).

Agroforestry

Agroforestry has been identified as the option with the greatest mitigation potential for the agriculture sector, besides providing other benefits. On-farm trees provide benefits for household consumption and sale including firewood, construction material, shade, fruit and timber. A good example is the Kenya Agricultural Carbon Project (KACP) in Western Kenya by Vi Agroforestry that aims to build farmers' knowledge on sustainable agricultural land management methods such as tree planting, composting and incorporation of crop residues. Farmers are encouraged to incorporate trees into their cropping systems from which participating farmers get carbon credits. In addition to earning income from the generated carbon credits, farmers are able to increase crop production, ensuring that their families are food secure and they remain with surplus for sale. Replication of these activities across other parts of the country will enhance resilience of farmers to climate change impacts, increase farm productivity and thus food security, increase farm incomes and contribute to reduction of emissions.

Agroforestry can mitigate climate change through creating and enhancing carbon sinks by capturing carbon from the atmosphere through photosynthesis and storing it in biomass and soil (KCSAP, 2017). Considering only the tree component of agroforestry systems, estimates based on growth rates and wood production from a limited number of studies show an average carbon stock in agroforestry systems between 9 and 63 Mg C ha/year depending on the climate (semi-arid to temperate) (Montagnini and Nair, 2004). However, carbon stocks in agroforestry systems of the tropics vary even for similar types of agroforestry systems due to the diversity of agroforestry practices (e.g., home gardens, windbreaks, intercropping, woodlots, etc.) and the impact of environmental (e.g., access to soil moisture, light and nutrients) and management (e.g., pruning and felling) factors suggesting the potential for agroforestry to be a low emission development strategy may be site specific (Reppin *et al.,* 2020).

Productive resources

Land resources

Accelerated agricultural development, land degradation and deforestation are key factors that influence the status of land resources in Kenya. Risk mapping of soil erosion in Kenya showed that all counties are experiencing some form of land degradation. The problem is more rampant in the ASALs where soils are highly erodible and the high intensity of storms creates favorable conditions for increased runoff and erosion. Degraded land allows the release of soil carbon (CO_2) into the atmosphere along with nitrous oxide (N_2O, both of which are important greenhouse gases. Soil has been indicated to be the largest terrestrial carbon sink and the loss of soil organic carbon is one of the most obvious signs of land degradation. Deforestation and forest degradation is another prominent problem in Kenya especially in the ASALs where increasing agricultural activities are claiming forested virgin land in an effort to meet the rising food demand. Deforestation and forest degradation lead to a decline in available carbon sinks and thus increased emissions.

Soils

Soil organic carbon (SOC) is a key indicator of soil fertility and agricultural lands productivity. Increasing SOC stocks (carbon sequestration) improves soil fertility and contributes to climate change mitigation. Studies on SOC sequestration rate in grasslands in Kenya ranges from 0.1 to 3.1 Mg C ha^{-1} $year^{-1}$ under different management strategies (Tessema, *et al.,* 2019). Grazing management is reported to have considerable impact on SOC sequestration rates and grassland regeneration and protection are recommended as options to stimulate SOC sequestration. Across agricultural landscapes, sustainable land management (SLM) has been identified as a promising approach for restoring degraded land while achieving additional benefits of carbon sequestration. Agroforestry has also been identified as viable and effective option for increasing SOC.

Water resources

Water resources have a very vital role in socio-economic development. However, increase in population growth and climate change has threatened its availability (Musau *et al.,* 2015). In addition, other challenges in the conservation and protection of water catchment areas include: weak institutional linkages and synergies; conflicting institutional mandates; lack of clear funding mechanisms for water catchment areas (WCA); lack of integrated WCA monitoring and evaluation systems; inadequate flow of information on WCAs;. low levels of awareness and capacity of stakeholders; degraded WCA; land degradation (and soil erosion) in WCA and poor management of water resources (MEMR, 2012). The restoration of watersheds through afforestation and re-afforestation programmes helps enhance the carbon sinks while providing other benefits such as timber, fuel wood, habitat for wildlife animals and reduces erosion.

Projects and programmes in climate change adaptation and mitigation relevant to agriculture

Some examples of programmes and projects on climate change adaptation and mitigation in agriculture are illustrated in Table 4.4 below.

Table 4.4. Programmes and projects on climate change and agriculture in Kenya.

Projects/ Programmes	Focal areas of climate change and Agriculture	Achievements and gaps
Mitigation of Climate Change in Agriculture Programme (2011-2014)	Mitigation, building resilience and improved agricultural productivity) GHG balance of the livestock production systems by improving animal breeds and their productivity in the Kaptumo Division of Nandi County.	While almost all (97 %) of the adopters of CSA practices perceived benefits, such as increased farm income. It thus reiterates the relevance to shift towards the design and adoption of more integrated production systems, not only to reduce GHG emissions, but mainly to increase and diversify agricultural production, while reducing vulnerability to climate change. Insights into the development of Nationally Appropriate Mitigation Actions (NAMAs) in the dairy sector of Kenya. Mitigation, capavity building, increased smallholder incomes, boost household food resilience, knowledge and skills, research , innovation and data
Agriculture Sector Development Support Programme I and II	Increase agricultural productivity and value addition, build social resilience, capacity development adaptation, market access	Develops sustainable value chains for improved income, and food and nutrition security, by increasing agricultural productivity, promoting investment, and encouraging private sector participation in agricultural enterprises and agribusiness
Kenya Climate Smart Agriculture Project	Increases agricultural productivity and builds resilience	Increases agricultural productivity and builds resilience to climate change risks in the targeted smallholder farming and pastoral communities in Kenya, and in the event of an Eligible Crisis or Emergency, to provide immediate and effective response.
Kenya Climate Smart Agriculture Project (2018)	Increase agricultural productivity and value addition, build social resilience, capacity development adaptation, mitigation; knowledge and information management, market and input access; and research, innovation and data	It aim to increase agricultural productivity and build resilience to climate change risks in the targeted smallholder farming and pastoral communities in Kenya, and provide effective response during eligible crisis or emergency through Its five components: up-scaling climate smart agricultural practices; strengthening climate-smart agricultural research and seed systems; supporting agro-weather, market, climate, and advisory services; coordination and management at national and county-levels including developing annual work plans and budgets (AWP&Bs),

		Weak polices, legislations, enforcement, and overlap of mandates among institutions involved in regulation coupled with poor coordination and collaboration among institutions and stakeholders in climate smart agriculture (CSA) have contributed to the country's inability to effectively address vulnerability and GHG emissions. Further, cross cutting issues such as inadequate financing of CSA activities; limited capacity of Women, Youth, and Vulnerable Groups (WY&VG) to participate in CSA activities; unsustainable natural resource management (NRM) and utilization; limited human resource capacity to undertake CSA; limited CSA research technology development and innovations; and inadequate data and information on CSA have also led to poor implementation of CSA activities.
Kenya Agricultural Productivity Project (I and II)	Building resilience, agricultural productivity, capacity building	Contribute to the revitalization of agriculture through four components: a) facilitation of sector policy and institutional reforms; support to extension system reforms; support to research system reforms: and support to Farmer/client Empowerment. The implementation of the M/E framework was unsatisfactory and gender and youth issues not well articulated including lack of evidence to substantiate improvements in yield
Economic Stimulus Programme: Agriculture- Food production	Building resilience, agricultural productivity, capacity building	Food Production: it aimed at increasing availability and accessibility of maize/rice crop and increasing and stabilizing the strategic grain reserve through rehabilitation and expansion of irrigable land
Economic Stimulus Programme: Agriculture- Fisheries	Capacity building, building resilience and increasing agricultural productivity	Fisheries focused on construction of200 farming ponds for 140 constituencies. Ponds are to be stocked with appropriate fingerling determined by the various and the needs of the beneficiaries. Training of trainers on fish ponds construction and hatchery management. It was politicized and technical expert opinions were ignored, misappropriation of funds and the sustainability was not well though especially in the ASAL counties. By 2018, only 20-46% of the farmers in the fisheries programme still continued with fish production while the rest had abandoned it.
Building Climate Change Resilience and Food Security Programme	Adaptation, building social resilience,	The Building Climate Change Resilience and Food Security Program is improving the productivity of smallholder farmers by promoting good farming practices and adoption of new technologies and agro-Entrepreneurship.
Climate Smart Agriculture, STARCK+		Supports scaling up of private sector innovation and investment in low carbon and adaptation products, services and assets (e.g. clean energy, sustainable agriculture, water management).
Kenya: Adaptation to Climate	Increases agricultural	Enhance the resilience of communities and the sustainability of rural livelihoods

Change in Arid Lands	productivity and builds resilience	threatened by climate change in the arid and semi-arid lands of Kenya.
Kenya Livestock Insurance Programme	Building resilience	It aimed at providing index-based insurance products to pastoralists that received pay out once satellite images indicated vegetation cover was below a certain threshold. The pastoralists utilised the payouts to purchase l feed, pasture, and water, to support their livestock during drought
Kenya National Agricultural Insurance Programme	Building resilience	Currently being piloted in three counties; Embu, Bungoma and Nakuru and it is based on Area Yield Index Insurance, the crop insurance framework benefited rural smallholder farmers and is based on the rainfall levels
Regional Pastoralist Livelihood Resilience Project	Building resilience, adaptation, market access and trade	Enhances livelihood resilience of pastoral and agro-pastoral communities in cross-border drought prone areas of selected countries and improve the capacity of the selected countries' governments to respond promptly and effectively to an eligible crisis or emergency through regional approaches. There are five components: natural resources management; market access and trade; livelihood support; pastoral risk management and; management and institutional support. It doesn't take into consideration Gender and youths.
Sustainable Land Management – Agro-Pastoral Risk	Building resilience, adaptation, capacity building	It provides the basis for economic development, food security and sustainable livelihoods while restoring the ecological integrity of the ASALs. The objective of the project will be "To provide land users and managers with the financial incentives, enabling policy, institutional and capacity for effective adoption of SLM in the pilot four districts (Mbeere North, Kyuso, Narok North and Dadaab). It mainstreams gender in its operations
Dairy NAMA	Mitigation, adaptation, increasing agricultural productivity, household income	Aims to transform Kenya's dairy sector to a low-emission and climate resilient development pathway by reducing GHG emission intensities in the dairy sector by at least 3% below current levels while improving the livelihoods of more than 600,000 male and female dairy producers. Its four components namely increasing on-farm dairy productivity through private sector investment in gender-inclusive extension services and fodder supply; reducing high-emission energy use in the dairy sector; strengthening institutional and stakeholders' capacities for scaling-up low-emission and climate resilient dairy development; and project coordination and management.
Land-based Emissions Estimation	Building resilience, Capacity	It supports the Government of Kenya meet national and international reporting

in Kenya (SLEEK) Project	building and mitigation	commitments; and to plan, measure and track its progress on landscape restoration. Also, it is developing a system that can: report Kenya's GHG emissions to the UNFCCC; customize mitigation efforts informed by scientific data; plan and track REDD+ (Reducing Emissions from Deforestation and forest Degradation plus conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries) and land restoration programs; and inform decisions by ministries and agencies for sustainable land use. In agriculture, it is supporting the development of a decision support system (DSS) in parallel to the MRV system. The DSS, via a series of applications (Apps), has proven potential to contribute to socio-economic development in the Agriculture sector, Kenya's largest employer. SLEEK also has the potential to assist Kenya's forest sector to benefit from REDD+ markets It is currently led by international consultants and the national experts may have inadequate capacity to continue upon handing over of the project. In its design, gender lens was not factored but achieved by default
Kenya: Adaptation to Climate Change in Arid and Semi-Arid Lands Phase 2	Capacity building, building social resilience	Strengthened climate risk management and natural resource base-related knowledge; built institutional and technical capacity for improved planning and coordination, to manage climate risks; and invested in communities' priorities in sustainable land and water management and alternative livelihoods that help them to adapt to climate risk. MoD&P, World Bank, with incremental support from UNFCCC Special Climate Change Fund administered by UNDP Ending Drought Emergencies The Common Programme Framework operationalized
Small-scale Irrigation and Value Added Project (SIVAP)	Building resilience, increases income levels, agricultural productivity and market access	It increases incomes, food security, and nutrition along the agricultural value chain by raising agricultural productivity and improving agricultural market access for poor and marginalized communities in 11 counties in arid and semi-arid regions. It promotes women and youth engagement in
Kenya Climate Smart Agriculture Project (KCSAP)	Increase agriculture productivity, increase incomes, build resilience, adaptation and mitigation	that aims to increase agricultural productivity and build resilience to climate change risks in the targeted smallholder farming and pastoral communities in Kenya
Kenya Livestock Insurance Project (KLIP)	Building social resilience, capacity building	It aims to improve resilience to drought and enhance sustainable livelihood of communities in ASALs of Kenya.

Kenya Crop Insurance Project	Building social resilience, capacity building	It is a rainfall index insurance products that cover farmers against drought and excess rain. The regular provision of relevant rainfall measurements and thresholds would significantly increase farmers' willingness to pay for weather insurance index.. Mechanisms to reduce basis risk are also positively valued by farmers, but are marred with corruption and lack of transparency. Also, it is biased towards rainfall, yet there are climatic (Temperature, soils, topography, eytc). Besides, the metereological stations are sparsely distributed in the country, thus, may not represent the density required including the distance from the weather situation will be a radius of 30 km. Radious. Similarly, there are on-climatic factors that are driven by rainfall regimes such as pest and diseases that are included in the programme. Further the payment of the premium by the government may not be sustainable especially when there are recurrent crop failures, therefore, the private sector needs to be involved to drive the insurance sector and help understand the real value and benefit of agricultural insurance. Finally, offering contracts to small groups rather than individual farmers could increase insurance uptake. Fails to integrate gender issues,
Drought Resilience and Sustainable Livelihood Programme in the Horn of Africa - Kenya Project	Building resilience and adaptation	Develops regional systems to alleviate the negative impacts caused by the deteriorating environmental conditions in the Horn of Africa. Mechanisms will be established to enhance the availability of infrastructure for natural resources management (water and pastures) at the regional level (given the mobility of pastoralists across borders) and ensuring stability of the environment as well as the harmonious sharing of the resources in a sustainable manner.
Ending Drought Emergencies	Building resilience	The Common Programme Framework operationalised a commitment to end drought emergencies by June 2023 through a collaborative approach across sectors, Counties, and development partners. NDMA leads the efforts and establishes mechanisms such as the National Drought Contingency Fund which is guided by contingency planning and early warning systems
Kenya Cereal Enhancement Programme- Climate resilient Agricultural Livelihoods (KCEP-CRAL)	Increase agricultural productivity an Building resilience and adaptation	Climate Resilient Agricultural Livelihoods Window Grant funding to complement an International Fund for Agricultural Development (IFAD) loan, which seeks to build the capacity of farmers to adopt climate smart practices by promoting efficient water management, conservation agriculture, and crop insurance.
National Agricultural and Rural Inclusive Growth (NARIG) Project	increase agricultural productivity, building resilience	Its being implemented in 10 counties that include: Kiambu, Nakuru, Narok, Nandi, Transnzoia, Bungoma, Kwale, Kilifi, Samburu, and Baringo it aims to increase

	and adaptation	agricultural productivity and the profitability of targeted communities. The project supports the adoption of climate smart agriculture practices and processes, and will be complementary to the Kenya Climate Smart Agriculture Project.
Hunger Safety Net Programme	Building resilience	HSNP aims to reduce extreme hunger and vulnerability by delivering regular and unconditional cash transfers of Kshs. 5,400 every two months (starting from July 2016) to targeted households.
Integrated Programme to Build Resilience to Climate Change and Adaptive Capacity of Vulnerable Communities in Kenya,	Building resilience	Built resilience to climate change, and increased the adaptive capacity of vulnerable communities in Kenya. This USD 10 million programme was implemented by three executing entities; the Kenya Forest Research Institute (KEFRI), Tana and Athi River Development Authority (TARDA), and Coast Development Authority (CDA), and eight sub-executing entities. It covered five thematic areas: Food Security, Water Management, Coastal Management, Disaster Risk Management and Knowledge Management. The project was implemented in Marsabit, Kajiado, Kwale,Mombasa, Homa Bay, Laikipia, Machakos, Kisumu, Wajir, Makueni, Kiambu, Meru, Kitui, Kilifi, TaitaTaveta, Lamu, Tana River and Garissa Counties
Implementing a Resilience Framework to Support Climate Change Adaptation in the Mt. Elgon Region of the Lake Victoria Basin Project	Building social resilience and adaptation	Implementing a Resilience Framework to Improves scientific knowledge of climate change information, and demonstrates increased social and ecological resilience toward addressing climate vulnerability in the Mt. Elgon water tower.
Climate Smart Agricultural Productivity Project		This programme is an amalgamation of several climate change adaptation projects designed to address five thematic areas, namely, Food security; Water management; coastal management, disaster risk reduction and Knowledge management
Agriculture National and Rural Inclusive Growth Project	Agriculture productivity and increased incomes	Increases agricultural productivity and profitability for targeted rural communities in selected Counties, and in the event of an Eligible Crisis or Emergency, to provide immediate and effective response.
Kenya Integrated Climate Risk Management Project	Building social resilience	builds national and sectoral capacity for climate analysis that informs effective use of disaster risk reduction and adaptation resources
integrated Programme to Build Resilience to Climate Change and Adaptive Capacity of Vulnerable	Building social resilience and adaptation	Built resilience to climate change, and increased the adaptive capacity of vulnerable communities in Kenya. This USD 10 million programme was implemented by three executing entities; the Kenya Forest Research Institute (KEFRI), Tana and Athi River

Communities in Kenya		Development Authority (TARDA), and Coast Development Authority (CDA), and eight sub-executing entities. It covered five thematic areas: Food Security, Water Management, Coastal Management, Disaster Risk Management and Knowledge Management. The project was implemented in Marsabit, Kajiado, Kwale,Mombasa, Homa Bay, Laikipia, Machakos, Kisumu, Wajir, Makueni, Kiambu, Meru, Kitui, Kilifi, TaitaTaveta, Lamu, Tana River and Garissa Counties.
Water Towers Protection and Climate Change Mitigation and Adaptation	Adaptation and mitigation	Identified and developed integrated management plans for ecological and economical sustainable land use systems in the watershed systems that feed into lakes Victoria, Turkana and Baringo.
Kenya Water Security and Climate Resilience Project	Increase agricultural productivity and capacity building	Increased the availability and productivity of Irrigation and Water sectors, and built the capacity of water sector institutions, including in integrated and particularity basin planning.
Building A Strategic Framework For Aquaculture Education In Kenya	Capacity building	Maps out (scientifically/educationally) the present curricula and asses them against the results of a labour market analysis. Based on a SWOT analysis it will design a strategic vision text for the proper development of the educational landscape, defining the required competences, quality criteria and quality assessment tools.
2SCALE is an incubator program	Building resilience and market access	Focuses on establishing agribusiness clusters built around business champions. Champions are either entrepreneurial producer organizations or local SMEs that trade or process the produce of farmers. By providing support to these clusters, 2SCALE is developing products and markets for local consumer markets, preferably at the base of the pyramid
Climate-smart financial diaries for scaling in Kenya. Global Challenges Programme project	Research and innovation	Contributes to developing and up-scaling business model addressing three challenges: (1) designing a conducive financial environment that enables up-scaling, (2) identifying additional value chain partners to increase financial viability, (3) identifying constraints, opportunities and required policy interventions at the landscape level.
Inclusive and climate-smart business models in Ethiopian and Kenyan dairy value chains | Global Challenges Programme project	Research and innovation, and market access	Aims to describe business models of chain actors and supporters to identify opportunities for scaling up good climate smart practices. Six dairy value chain case studies were implemented in Kenya and three in Ethiopia, with varying degrees of market-orientation
Partnerships for climate resilient	Capacity building	Supports regional, continental and global Nations Framework Convention on Climate

agriculture and food systems		Change (UNFCCC) work program on agriculture, specifically supporting the African Group of Negotiators (AGN), policy makers processes to fully contribute to the United, civil society organizations and marginalized groups to build their capacity to participate in policy development to improve food security and climate-smart agriculture
Scaling up Climate-Smart Village models in East Africa	Research and innovation, and market access	Explores innovations, institutions and business models for building the network of Climate-Smart Villages in East Africa and supporting local adaptation planning
Climate Resilient Agri-business For Tomorrow	Increased agricultural productivity and building resilience	Contributes to increased availability of accessible and climate resilient food for the growing population in Kenya, Tanzania and Uganda.
System for Land-based Emissions Estimation in Kenya (SLEEK) Programmes	Capacity building, and mitigation	Aims to help the Government of Kenya meet national and international reporting commitments; and to plan, measure and track its progress on landscape restoration. SLEEK is developing a system that can: Report Kenya's greenhouse gas emissions to the United National Framework Convention on Climate Change (UNFCCC); Customize mitigation efforts informed by scientific data; Plan and track REDD+ (Reducing Emissions from Deforestation and forest Degradation plus conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries) and land restoration programs; and Inform decisions by ministries and agencies for sustainable land use.
Improving Smallholder Productivity & Profitability (ISPP)	Adaptation, building resilience and capacity building,	Builds smallholder farmers' skills in agricultural production, water management and in farming as a business in five semi-arid counties. ISPP is increasing household food security and nutrition through improved access and efficient management of water, the use of climate-resilient agricultural practices and agribusiness promotion.
Empowering Novel Agribusiness-Led Employment (ENABLE) Youth Kenya Program	Capacity building, increase income and gender and youths	Builds entrepreneurship in agri-business via skill acquisition and creates an enabling environment in which young men and women become owners of profitable agribusinesses.
Feed the Future	Increased agricultural productivity and building resilience, and capacity building,	Enhance food security and increase incomes through improving the competitiveness and diversity of agricultural market systems and livelihoods

Low Emission and Climate Resilient Development (LECRD) Project	Increased agricultural productivity and building resilience, and capacity building, adaptation and mitigation	strengthen the national climate change coordination processes; contribute toward enhancing access to clean and efficient energy systems; support development of a national sustainable greenhouse gas (GHG) inventory system; facilitate improved national and county-level decision making on climate change interventions; support capacity building of a climate knowledge management system; and contribute towards minimizing the impacts of extreme climate events for improved and resilient livelihoods.
Green Climate Fund Readiness Programme- Kenya	Capacity, building, adaptation and mitigation	Develop the capacity of stakeholders in Kenya to plan for, access, manage, and monitor climate change finance at the national and sub national levels. It builds and strengthens the institutional capacity of national entities in Kenya, with a focus on enabling direct access; and to b) helps Kenya prepare climate change mitigation and adaptation investment strategies, programmes and projects, including through the active involvement of the private sector.
Smallholder Innovation For Resilience (SIFOR)	Capacity building and building of resilience	Strengthen bio-cultural innovation for food security in the face of climate change, in China, India, Kenya and Peru.

Capacity building

This study mapped 32 programmes and projects in Table 4.4 above. This table shows that within the MOAL&F, there are no specific programmes on capacity building on agriculture and or climate change at national and county levels. However, there are few projects specifically on capacity building projects in agriculture or climate change by non-governmental actors such as FAO, SIFOR, UNDP, CCAFS and KMFRI among others. Most of the agriculture or climate projects have short term training components rather than long term capacity building plans. Moreover, these trainings are not well structured and quite often lack continuity and follow-up plans to monitor the added value of the training in service delivery. It's more focused on delivering the project or programme objectives. In addition, the projects in agriculture have focused more on delivering the increase productivity and income objectives and quite often the adaptation goal including building of resilience has been achieved by default. Given the complexity of the interaction between agriculture and climate change, it is important to have a more structured capacity building programme that is continuous and there are framework to monitor the added value of the capacity building initiatives to service delivery Therefore, the capacity building within the CSA agriculture provides an opportunity for the national government to adequately design a long term plan for capacity of the counties in to integrate the goals of both agriculture and climate change

Enabling policy environment

Overview

Climate change is undoubtedly the most severe challenge facing our planet during the 21st century. Human interference with the climate system has increased the global and annual mean air temperature at the Earth's surface by roughly 0.8oC since the 19th century (IPCC, 2013). This trend of increasing temperatures will continue into the future: by 2100, the globe could warm by another 4oC or so if emissions are not decisively reduced within the next decades (IPCC, 2013). There is broad agreement that a warming of this magnitude would have profound impacts both on the environment and on human societies (IPCC, 2014a), and that climate change mitigation via a transformation to low emissions, climate resilient development pathways and societies has to be achieved to prevent the worst of these impacts (IPCC, 2014b).The global nature of climate change calls for collective global response and cooperation by all countries and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions. Combating climate change would require substantial and sustained reductions in GHG emissions which, together with adaptation can limit climate change risk.

Global frameworks

To ensure collective global response to the threat of climate change, several international instruments have been established. The instruments are discussed below.

UNFCCC and synergies with the other Rio Conventions (CBD and CCD)

The United Nations Framework Convention on Climate Change (UNFCCC) is an intergovernmental treaty developed to address the global challenge of climate change. The Convention, which sets out an agreed framework for a global response to climate change was adopted in June 1992 in Rio de Janeiro, Brazil at the Rio Earth Summit. The UNFCCC entered into force on 21 March 1994. The ultimate objective of the Convention is to *"stabilise greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system"* and which *"should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner".*

The Convention divides the world into two groups: developed (western countries and eastern countries with economies in transition listed in Annex I) and developing countries. Annex I countries were encouraged to reduce their emissions of CO_2, N_2O and CH_4 in the year 2000 to the 1990 levels. Developed countries listed in Annex II (a sub-set of Annex I) are expected to provide finance, technology and capacity building support to the developing countries taking full account of the specific needs and special situations of least developed countries and small island countries. Since it is a framework instrument to operationalize its provisions, other instruments have to be established. Since then two instruments have been established under the Convention, namely: Kyoto Protocol (1997) and Paris Agreement (2015).

Kyoto Protocol

The Kyoto Protocol (KP) was adopted in 1997 and came into force in 2005. The main objective of the Protocol is to reduce emissions of Annex I countries by at least 5% below 1990 levels (and in some cases 1995 levels) in the period 2008-2012. Individually, these countries had separate commitments. The European Union countries were collectively expected to reduce their emissions by 8%, the USA by 7% and Japan by 6%. Australia, Iceland and Norway were allowed to increase their emissions. The remaining countries were allowed varying levels of reduction. The Protocol identifies policies and measures that can be taken by countries (Art. 2) and quantified commitments for Annex B countries on six GHGs.

The Protocol established three flexible mechanisms: joint implementation (JI, Art. 6) with crediting among the developed country Parties; Clean Development Mechanism (CDM, Art. 12) which aims at enabling projects in developing countries to achieve sustainable development, contribute to the ultimate objective of the Convention and assist developed countries in complying with their quantified emission reduction and limitation commitments; and the emission trading (ET, Art. 17) among themselves. The mechanisms were founded on division of a budget of permissible emissions among countries (cap and trade system). Those countries that do not use their complete share may sell the unused portion to those who need them. The assigned amounts (or quotas) were allocated to the developed countries and the quotas were equivalent to their emission reduction commitments. The underlying rationale of these co-operative mechanisms is to ensure that global emissions of greenhouse gases are reduced in a cost-effective manner. The first commitment period of KP started in 2008 and ended in 2012. The Doha Amendment to the KP adopted in 2012 established the second commitment period for developed countries to reduce their GHG emissions by at least 18% by 2020 below 1990 levels. Unfortunately, to date the Doha Amendment is yet to attain the requisite number of countries that have ratified it for it to come into force. The effect of this is that the KP and its Doha Amendments will come to an end at the end of this year (2020).

That notwithstanding, the KP made some useful achievements. These include: introduction of a multinational carbon market; delivery of new rules for reporting, accounting and verifying emissions; support to developing countries through the establishment of the Adaptation Fund; incentivising green investments in the developing world; and the institution of rules-based architecture.

Paris Agreement on Climate Change

Purpose of the Agreement

In negotiating the Paris Agreement, every effort was made to avoid the shortcomings of the KP. The Paris Agreement on Climate Change was adopted at COP21 in 2015 in Paris, France and came into force in November 2016. The Agreement applies to all countries and expects each country to play its role and moves away from the dichotomy of Annex 1 and Non Annex 1 countries. The purpose of the Agreement is set out in Article 2 to enhance implementation of Article of the Convention and to strengthen the *collective global response to climate change*. The three elements underpinning the purpose are:

- Holding the average global temperature to well below 2oC above pre-industrial levels and to ensure that efforts are pursued to limit the temperature increase to 1.5oC;
- Enhancing adaptation and resilience and synergies between adaptation and mitigation; and
- Making finance flows consistent with low emissions, climate resilient development pathway.

The long term temperature goal includes two targets for maximum global warming, countries commit to "[hold] the increase in the global average temperature to well below 2^{o}C above pre-industrial levels", and "to pursue efforts to limit the temperature increase to 1.5°C". However, according to the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°, "without societal transformation and rapid implementation of ambitious greenhouse gas reduction measures, pathways to limiting warming to 1.5°C and achieving sustainable development will be exceedingly difficult, if not impossible, to achieve." The effect of this is that the risks for human well-being and livelihoods, food, water and ecosystem security, which are already significant and disproportionally affecting vulnerable people and communities, will be severely higher at 1.5°C. The risks will increase further with every level of additional warming, particularly affecting already disadvantaged and vulnerable populations. Comparing the adaptation needs in a 1.5°C and 2°C scenario based on global exposure to 14 impact indicators — the IPCC SR concludes that the agricultural, water, energy and coastal sectors cost the most to become resilient, and that adaptation risks and costs increase 2.5 fold between 1.5°C and 3°C.

Global Goal on Adaptation (GGA)

Adaptation is recognized as a key component of the long term global response to climate change and an urgent need of developing countries. Article 7 of the PA establishes an aspirational global goal on adaptation (GGA) to *enhance adaptive capacity, strengthen resilience and reduce vulnerability to climate change* (Art. 7.1). The importance of continuous and enhanced support for adaptation efforts of developing countries particularly vulnerable to the adverse effects of climate change are also recognized. The PA provides that adaptation should follow a country-driven, gender-responsive, participatory and transparent approach that takes into account the interests of vulnerable groups, communities and ecosystems. Adaptation action should be based on and guided by *"the best available science and, as appropriate, traditional knowledge, knowledge of indigenous peoples and local knowledge systems, with a view to integrating adaptation into relevant socioeconomic and environmental policies and actions, where appropriate".* Each developing countries is required, as appropriate, to engage in adaptation planning processes and the implementation of actions, plans and policies such as, for example, *formulating* *national adaptation plans (NAPs),* assessing climate change impacts and vulnerability and building resilience (Art. 7.9).

Means of Implementation (finance, technology and capacity building)

Means of Implementation (finance, technology and capacity building) are crucial for supporting developing countries to transition to low emissions, climate resilient development pathways.

Finance: Article 9 of the PA provides that $100 billion in public and private resources will need to be raised each year from 2020 (first announced at COP15 in 2009 held in Copenhagen, Denmark) and will continue until 2025. The said financial resources will finance policies, programmes and projects that enable developing countries to adapt to the impacts of climate change and/or reduce GHG emissions. The Agreement includes the provision that financial resources should aim to achieve a balance between adaptation and mitigation, taking into account country-driven strategies, the priorities and needs of developing countries, in particular LDCs and SIDS. The UNFCCC's Financial Mechanism, including its operating entities – Green Climate Fund (GCF), Global Environment Facility (GEF), Adaptation Fund (AF), Least Developed Countries Fund (LDCF) and Special Climate Change Fund (SCCF) - will serve as the financial mechanism of PA. The institutions serving the Agreement have to aim to ensure efficient access to financial resources through simplified approval procedures and enhanced readiness support (Art. 9.9).

On **technology development and transfer**, Article 10 of the PA requires countries to strengthen cooperative action on technology development and transfer and establishes a technology framework to provide overarching guidance to the work of the Technology Mechanism established under the Convention. The Technology Mechanism consists of the Technology Executive Committee (TEC) tasked with policy analysis, recommending actions and facilitating cooperation for technology development and transfer a Climate Technology Centre and Network (CTCN) responsible for facilitating a network of organizations in order to provide technical assistance to developing countries. The Technology and Financial Mechanisms of the UNFCCC, along with other actors or institutions, are required to support efforts to accelerate, encourage and enable innovation for collaborative approaches to research and development and facilitating access to technology [...]to developing countries (Art. 10.5).

With respect to **capacity building**, Article 11 of the PA emphasizes capacity building needs of developing countries, in particular those with the least capacity and those that are particularly vulnerable to the adverse effects of climate change, such as LDCs and SIDS. It underlines capacity to: implement adaptation and mitigation actions; facilitate technology development, dissemination and deployment; and access climate finance among others. It establishes a Paris Committee on Capacity Building (PCCB) as a permanent body under the Agreement to address capacity gaps and needs , both current and emerging, in developing countries and to enhance capacity building efforts and requires countries that enhance the capacity of developing countries to regularly communicate on capacity building actions or measures (Art. 11.4).

Sustainable Development Goals

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030.The SDGs that have direct linkto agriculture and climate change include: SDG1 (no poverty, where the sector creates employment, produces food reducing poverty); SDG 2(zero hunger is dedicated to ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture.),Goal 3 (Good Health and Well-being); Goal 4: (Quality Education); Goal 5 (Gender Equality); Goal 7 (affordable and clean energy and Goal 8 (Decent Work and Economic Growth), Goal 13 on climate action include adaptation and mitigation through strengthening resilience and adaptive capacity to climate-related risks, (early warning; improving human and institutional capacity, policies and legislation). Kenya has integrated the SDGs in its Third Medium Term Plan and in other relevant macroeconomic and sectoral policies.

Sendai Framework on Disaster Risk Reduction

Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030 is the main instrument for Disaster Risk Management (DRM) in the countries to foster sustainable development and eradicate poverty through substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. The framework has four priority areas including: understanding disaster risk; strengthening disaster risk governance to manage disaster risk; investing in disaster risk reduction for resilience; and enhancing disaster preparedness for effective response and to 'Build Back Beer' in recovery, rehabilitation and reconstruction. The framework advocates for the integration of both DRR and resilience-building into policies, plans, programmes and budgets at all levels and is aligned with other global frameworks like the SDGs and Paris Agreement. The Framework emphasises the need for a more coherent risk sensitive development policies for most vulnerable sectors, including agriculture and food security, and the role of social safety-net mechanisms in the realm of food security and nutrition. The need to protect agriculture and productive assets including livestock, working animals, tools and seeds are specifically referred. The African Union has established a specialized agency - *The African Risk Capacity (ARC)* –to support member states on disaster risk management and building resilience.

Regional frameworks

Continental level

There are several continental policies and frameworks that are relevant to Kenya and promote both agriculture growth and development and or ensure development pathways that are climate resilient.

AU Agenda 2063

Agenda 2063 is Africa's blueprint and master plan for transforming Africa into the global powerhouse of the future. It recognizes sustainable agricultural production and the need to modernize the Agriculture for increased productivity and production with agricultural productivity and production as a priority. Also, it emphasises on promoting environmentally sustainable and climate resilient economies and communities by prioritizing: sustainable natural resource management and biodiversity conservation; sustainable consumption and production patterns; water security; climate resilience and natural disasters preparedness and prevention; and renewable energy. Other priority areas relevant to the Kenyan efforts in agriculture and climate change include education and STI skills driven revolution, health and nutrition, reduction in poverty, inequality and hunger and management of marine resources and energy.

Maputo Declaration on Agriculture and Food Security and the Comprehensive African Agriculture Development Program (CAADP)

The Maputo declaration on Agriculture and Food Security was signed by the African Union Assembly in 2003 with the aim of returning agriculture to the center of the agenda. Countries committed to allocate at least 10% of their national budgetary allocations to agriculture with the aim of achieving 6% growth of the agriculture economy through the Comprehensive African Agriculture Development Program (CAADP) flagship program under the African Union Development Agency (AUDA-NEPAD). The CAADP has four (4) priority areas namely: a) Extending the area under sustainable land management and reliable water control systems; b) Improving rural infrastructure and trade-related capacities for market access; c) Increasing food supply, reducing hunger, and improving responses to food emergency crises and d) Improving agriculture research, technology dissemination and adoption in livestock, forestry and fisheries. The Malabo declaration for accelerated agricultural growth and transformation for shared prosperity band improved livelihoods adopted by the AU Summit in 2014 to re-energize the CAADP program. The declaration aimed to reaffirm the commitment made by the Maputo declaration for 10% of national budget allocations to agriculture. The Malabo declaration calls for investment in social protection with a special focus on women and youth and agribusiness programs as critical elements of national investment plans.

Africa Regional Nutrition Strategy

The ARNS was first developed in 2005, for the period 2005 – 2015.The revised ARNS is for the period 2015 – 2025. It aims to improve nutrition in the continent of Africa through successful implementation through a 40% reduction of stunting among children under 5 years; 50% reduction of anaemia among women of child-bearing age; 30% reduction of low birth weights; no increase of overweight in children under 5 years of age and women; 50% increase in exclusive breast-feeding during the first six months of life; and to reduce and maintain wasting among children under 5 to less than 5%. This strategy recognizes the role of agriculture, food and nutrition in Africa, and the needs for its rapid transformation to provide household food and nutrition. However, it has failed to take into recognition climate change issues (Amwata et al. 2020).

Science Technology Innovation Strategy for Africa

The AU Science, Technology and Innovation Strategy for Africa places science, technology and innovation at the core of Africa's socio-economic development and growth and the impact the sciences can have across critical sectors of development such as agriculture, energy, environment, health, infrastructure development, mining, security and water among others. The strategy envisions an Africa whose transformation is led by innovation and which will create a knowledge-based economy. STISA is anchored on six (6) priority areas of which two of these areas are aligned to agriculture focusing on Eradication of Hunger and Achieving Food Security and climate change that focus on Protection of our Space. Other areas include Prevention and Control of Diseases, Communication (Physical and Intellectual Mobility), Living together in peace & harmony to build the society and Wealth Creation. The priority area on eradication of hunger focuses on agriculture/Agronomy in terms of cultivation technique, seeds, soil and climate; Industrial chain in terms of conservation and/or transformation and distribution and infrastructure and techniques.

Sub-regional level

The sub-regional policies and frameworks relevant to Kenya include those from COMESA, IGAD and East African Community as described below.

Intergovernmental Authority on Development (IGAD)

Kenya is a Member State of the Intergovernmental Authority on Development (IGAD) is an 8-country trade bloc in Africa to which Kenya has been a founding member since 1986. Part of the mandate of IGAD is to mitigate the effects of drought, desertification and food insecurity in the region, in line with the African Union missions. IGAD has put in place a framework for improving the efficiency of agricultural and food marketing in the region. As a response to climate change impacts (e.g. drought and floods) which the IGAD region has experienced, several initiatives have been put in place including the development of a regional climate change strategy, drought and disaster resilience and sustainability initiative. These include the IGAD Livestock Policy Initiative that has resulted in the development of the National Livestock Policy Hub in Uganda, the IGAD Fertilizer and Inputs Programme, the Regional Food Security Programme, IGAD Strategy and Implementation Plan 2016-2020 and Livestock Marketing Information System. The IGAD Climate Centre (ICPAC) is an important climate centre for the region.

East African Community (EAC)

Kenya is a Partner State of the East African Community (EAC) Vision 2050 was adopted in 2016 to provide a catalyst for enhancing regional growth and development and operates within the framework of Africa Union Agenda 2063. Agriculture, food security and the rural economy as well as environment and natural resource are among the key pillars in the policy. Further, the EAC Vision 2050 seeks to promote value addition through agro-processing. The AfCFTA aims to create a single market for goods and services facilitated by movement of persons in order to deepen the economic integration of the African continent. This is an opportunity for Uganda to exploit its agro-industrialization agenda in order to feed the global value chain. The Uganda Vision 2040 puts emphasis on the establishment of economic lifeline industries including agro-based industries to drive agriculture productivity. Various important EAC instruments such as the EAC Food and Nutrition Security Policy (2014), EAC Agriculture and Rural Development Policy (2006), East African Community Climate Change Master Plan (EACCCMP), East Africa Climate Change Strategy, EAC Climate Change Policy,2015 Disaster Risk Reduction and Management Act, the 2016 EAC Forest Management and Conservation Bill, the 2010 EAC Trans boundary Ecosystem Management and Conservation Bill (2010), and the 2006 Protocol on Environment and Natural Resources exist in East Africa.

Common Market for Eastern and Southern Africa (COMESA)

Kenya is a Member State of the Common Market for Eastern and Southern Africa (COMESA) the regional economic community of the African Union. COMESA's core mandate is to enhance regional integration especially agricultural trade. This is by opening up the region to allow free flow of agricultural trade by removing all barriers to such trade to ensure that as needed, commodities move from surplus to deficit areas in the region driven primarily by demand and market forces. The other strategic approach is to put in place policies, systems, regulations and procedures which are harmonized across the region so as to create a conducive, transparent and facilitative environment for conducting regional agricultural trade with forward and backward linkages across the region from the farmer to the market.

National policies

Macro-economic policy framework

Constitution of Kenya

The Constitution of Kenya, 2010, is the supreme law governing the country. It provides a framework on domestication of international and regional treaties and conventions. The Constitution establishes two levels of governments: national and 47 county governments and sets out their functions. One of the functions that is fully devolved to the county governments is agriculture with the national government being responsible for agriculture policy.

Kenya Vision 2030

Kenya Vision 2030 – the country's development blueprint – aims at transforming Kenya into "a newly industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment by the Year 2030". In its Mid-Term PlansVision 2030 recognizes agriculture as a key sector to boost economic growth rates through the transformation of smallholder agriculture from low-productivity subsistence activities, to an innovative, competitive agricultural sector and recognizes climate change as a risk that could slow the country's development. Vision 2030 recognizes the role of agriculture in the achievement of a sustained GDP growth rate of 10% annually in Kenya. The Third Medium Term Plan (2018-2022) have recognized climate change as a cross-cutting thematic area and the need for its mainstreaming in the sectoral strategies and plans.

Green Economy Strategy and Implementation Plan (GESIP) (2016-2030)

The Green Economy Strategy and Implementation Plan (GESIP) underpins Kenya's commitment to undertake a transition to a green economy in line with the outcome of the United Nations Conference on Sustainable Development (UNCSD) held in 2012 (Rio+20 Summit). The GESIP emphasises synergies between economic development, the SDGs and climate change. It identifies five themes: (1) infrastructure development, (2) building resilience, (3) resource efficiency, (4) sustainable natural resource management, and (5) social inclusion and sustainable livelihoods.

Big Four Agenda (2018-2022)

The Big Four Agenda establish priorities areas for 2018 to 2022 of ensuring food security, affordable housing, increased manufacturing and affordable healthcare. The sector plans and budgets are to be aligned to the Big Four priorities. The food security agenda is being achieved through three innovative initiatives namely: enhance large scale production, drive small-holder productivity and reduce the cost of food. Enhancing large scale production involves placing an additional 700,000 Acres through PPP (including idle arable land) under maize, potato, rice, cotton, aquaculture and feeds production; forming an Agriculture and Irrigation Sector Working Group (AISWAG) to provide coordination for irrigated Agriculture; using locally blended fertilizer on a 50/50 basis and implement liming e.g. maize; and availing incentives for post-harvest technologies to reduce postharvest losses from 20% to 15% e.g. waive duty on cereal drying equipment, hematic bags, grain cocoons/silos, fishing and aquaculture equipment and feed. Driving smallholder productivity entails access to credit; establishment of commercialized feed systems for livestock, fish, poultry and piggery to revolutionize feed regime and traceability of animals; and establishment of East Africa's Premier food hub and secure investors to construct a Shipyard.

Relevant sectoral policies

National Livestock Policy, 2008 – Revised 2015

The National Livestock Policy identifies measures to enable the livestock sub-sector enhance its contribution to food and nutritional security, provide raw materials for agro-based industries and contribute to improved livelihoods in the country. Emphasis is placed on improving livestock management systems for sustainable development of the livestock industry. The Policy identifies high frequency and increased severity of droughts as one of the effects of the climate change phenomenon. Due to frequent droughts that affect livelihoods that are dependent on livestock, the Policy proposes to establish a livestock insurance scheme to be realized through a public-private-partnership model.

Kenya Food and Nutrition Security Policy, 2012

Kenya's Food and Nutrition Security Policy (FNSP) provides a multi-sectoral framework that encompasses all the four dimensions of food security (availability, accessibility, stability, and utilization). The Policy outlines interventions to be implemented by the relevant ministries to effectively address the challenge posed by food and nutrition insecurity. The process of developing an implementation framework for the FSNP is ongoing and is envisaged to institutionalize a multi-sectoral mechanism for its implementation.

National Agricultural Research Systems Policy, 2012

The National Agricultural Research Systems (NARS) Policy provides the framework for research in the agricultural sector and aims at achieving reforms in the Kenyan agricultural research systems to support the development of an innovative, commercially oriented, and modern agricultural sector. The Policy objectives include:(a) problem-solving and impact driven research agenda, (b) fast-tracking national adoption of available technologies and knowledge and (c) enhancing capacity to access and adopt knowledge and appropriate technologies available world-wide. The Policy refocuses research to solve problems, the harnessing of indigenous knowledge while upholding professional ethics and the adoption of innovative methods of knowledge transfer. The Kenya Agricultural and Livestock Research Act provides the legal and institutional framework of the agricultural research in the country. It establishes the Kenya Agricultural and Livestock Research Organization (KALRO) to replace the Kenya Agricultural Research Institute (KARI).

National Oceans and Fisheries Policy, 2008

The National Oceans and Fisheries Policy, 2008 promotes the ecosystem-based sustainable exploitation of fishery resources. The policy proposes to use adaptive and environmentally sustainable technologies and best international practices in aquaculture development. It emphasizes high standards in fish handling to minimize post-harvest losses.

Agricultural sector growth and Transformation strategy, 2018

The new agricultural development strategy - Agricultural Sector Transformation and Growth Strategy (ASTGS) is for the period 2019-2029. This replaces the Agricultural Sector Development Strategy (ASDS 2010–2020) the agriculture blueprint document that has guided the development in the agricultural sector for the past decade. The ASTGS outlines and sets national goals and targets of key food security and value chain priorities on which the county agricultural sector planning and investments would be based. It also provides for the integration of an inter-ministerial and intergovernmental coordination mechanism to ensure close cooperation between the two levels of government. The ASTGS is closely linked to the r National Agriculture Investment Plan (NAIP) that is intended to identify priority investments and the level of support needed in order to achieve the ASTGS goals and targets.

Kenya Climate Smart Agriculture Strategy 2017-2026

The main objective of the Kenya Climate Smart Agriculture Strategy (KCSAS) is to adapt to climate change, build resilience of agricultural systems while minimizing emissions for enhanced food and nutritional security and improved livelihoods. The KCSAS identifies four broad strategic areas, namely: (i) Adaptation and building resilience by addressing vulnerability due to changes in rainfall and temperature, extreme weather events and unsustainable land/water management and utilization; (ii) Mitigation of GHG’s emissions from key and minor sources in the agriculture sector; (iii) Establishment of an enabling policy, legal and institutional framework for effective implementation of CSA; and (iv) Minimizing effects of underlying cross-cutting issues such as human resource capacity and finance. The KCSAS recognizes the vulnerability of pastoral communities and the need for adaptation.

Kenya Climate Smart Agriculture Framework Programme 2015-2030

The Kenya Climate Smart Agriculture Framework Programme provides guidelines for implementing climate smart agriculture approaches, practices and technologies across the country. The objectives of the Programme include: i) enhancing agricultural productivity ii) building resilience and associated mitigation co-benefits through CSA iii) value chain integration iv) improving and sustaining agricultural and agro weather advisory services; and v) improved institutional coordination. The Programme also emphasises the need to transition to low carbon, climate resilient development pathway. Specific measures address specifically women and youth issues have been identified.

Farm Forestry Rules, 2009

The Farm Forestry Rules regulate establishment and maintenance of farm forestry such as woodlots or trees on farms) on at least 10% of every agricultural land holding. It requires farmers to choose the right species of trees or varieties that do not adversely affect water sources, crops, livestock, soil fertility and the neighborhood and must not be of invasive nature. This is a function that is supposed to be regulated by the County Governments.

National climate change policies

National Climate Change Framework Policy, 2017

The National Climate Change Framework Policy aims to enhance climate resilience and adaptive capacity, promote low carbon growth and to mainstream climate change into planning processes. The Policy recognises agriculture as one of the sectors that are highly vulnerable to climate change but with greatest mitigation potential to reduce GHG emissions. Some of the practices that could contribute to sequestration and emission reduction include: a) sequestration of carbon in trees and soils through agroforestry, b) improved pasture and range land management, c) conservation agriculture, d) efficient dairy production systems, and e) improved manure management. The Policy outlines the legal and institutional framework. The

Climate Change Act provides the legal and institutional framework of climate change in the country.

National Climate Finance Policy, 2018

The National Climate Finance Policy provides for the establishment of legal, institutional and reporting frameworks to access and manage climate finance. The goal of the Policy is to further Kenya's national development goals through enhanced mobilisation of climate finance that contributes to low carbon, climate resilient development goals.

National Climate Change Response Strategy, 2010 and Action Plan, 2012

The National Climate Change Response Strategy (NCCRS)outlines climate change impacts on the country and recommended actions that the country needs to take to reduce these impacts as well as take advantage of the beneficial effects of climate change. These actions range from adaptation and mitigation measures in key sectors including agriculture. Some of the interventions include: Adaptation: i) restoration of degraded ecosystems, ii) provision of downscaled weather information, iii) water harvesting for irrigation, iv) protection of natural resource base (soil and water conservation techniques), v) agroforestry, agronomic management practices and climate risk management tools such as insurance. The mitigation actions include: i) agroforestry and agronomic management practices, ii) improved management of grazing systems, iii) improved feeds and forage conservation and storage biogas, iv) livestock diversification, and v) improved breeding of animals. The NCCRS emphasizes diversifying sources of climate finance including public and private sector climate finance from both domestic and international sources and carbon markets to support adaptation and mitigation actions in the country.

Kenya National Adaptation Plan 2015-2030

The Kenya National Adaptation Plan (NAP) for the period 2015-2030 sets out the medium and long term adaptation actions that the country plans to implement for the period 2015-2030.The objectives of the NAP are: a) highlight the importance of adaptation and resilience building actions in development; b)integrate climate change adaptation into national and county level development planning and budgeting processes; c) enhance the resilience of public and private sector investment in the national transformation, economic and social and pillars of Vision 2030 to climate shocks; d) Enhance synergies between adaptation and mitigation actions in order to attain a low carbon climate resilient economy; and e) enhance resilience of vulnerable populations to climate shocks through adaptation and disaster risk reduction strategies. The NAP identifies short, medium and long-term actions that enhance resilience in the agriculture, livestock and fisheries value chains.

Kenya's Nationally Determined Contribution, 2016

Kenya submitted her Intended Nationally Determined Contributions (NDC) in 2015 ahead of the twenty-first Conference of the Parties (COP21) held in 2015 in Paris, France. With adoption of the PA, Kenya signed and ratified the PA in 2016 and reconfirmed her INDC as the first NDC under the Agreement. The NDC has both adaptation and mitigation actions. On the adaptation, the NDC aims to increase ability to adapt and build climate resilience. On mitigation, it recognizes her mitigation potential and proposes to abate its GHG emissions by 30% by 2030 relative to the BAU scenario of 143 MtCO2eq. However, this would require international support in the form of finance, investment, technology development and transfer and capacity development in accordance with the provisions of the Convention and the Paris Agreement. The NDC identified agriculture sector through climate smart agriculture actions as one of the priority adaptation and mitigation action areas to contribute the achievement of the target.

Agriculture flagship projects

The National Agriculture and Livestock Extension Programme (NALEP)

NALEP is one of the major contributors to improved growth of the agricultural sector. The programme is implemented by the Ministry of Agriculture (MoA) and the Ministry of Livestock Development (MoLD) as a reform programme within the framework of the National Agriculture Sector Extension Policy Implementation Framework (NASEP-IF). The four year Programme (2007-2011) has a national coverage. Its overall goal is to contribute to socio-economic development and poverty alleviation, through promotion of sustainable technologies for natural resource management in agriculture and livestock production. Its long-term purpose is: To increase effectiveness of integrated extension services to farmers and agropastoralists. To achieve the above goal, the Programme has identified the following specific objectives: a) To institutionalize demand-driven and farmer-led extension services; b) To increase the effectiveness of pluralistic provision of extension services; c) To increase the participation of private sector in providing extension services; d) To empower farmers to take charge of Project Cycle Management of extension projects; e) To develop accountability mechanisms and transparency in delivering extension services; f) To facilitate commercialisation of some of the agricultural extension.

National Agricultural Insurance Programme

In March 2016, the Government of Kenya launched the Kenya National Agricultural Insurance Programme to address the challenges that agricultural producers face when there are large production shocks, such as droughts and floods. Through the new Kenya Livestock Insurance Program (KLIP), the government will purchase drought insurance from private insurance companies on behalf of vulnerable pastoralists. Satellite data is used to estimate the availability of pasture on the ground and triggers pay- outs to pastoralists when availability falls. KLIP was introduced in October 2015 for 5 000 pastoralists in Turkana and Wajir and is envisaged to be scaled across the region by 2017. For maize and wheat, the programme addresses these challenges through an “area yield” approach: farming areas are divided up into insurance units: if average production in one of the units falls below a threshold, all insured farmers in the unit receive a pay-out. The programme is starting up in Bungoma, Embu, and Nakuru and plans to reach 33 counties by 2020. KLIP introduces a state-of-the art method of collecting crop yield data, using statistical sampling methods, GPS-tracking devices, and mobile phones. This partnership between the government and the private sector is innovative and this programme could pave the way for other large-scale agricultural insurance programmes in Africa.

There are a large number of projects and programmes supported by donors and the government of kenya in agriculture. These projects encompass a wide range of issues, starting from technological innovation through expanding natural resource use, improved marketing infrastructure, institutional capacity development, policy and institutional reforms and multifunctional investments. The main areas of intervention of these programmes include: a) Food security and nutrition programmes b) Safety nets c) Improving access to farm inputs d). Agricultural advisory services e) Agri-business development f)). Improving natural resources management g) Institutional support (capacity building) and g) building community resilience on in overall, the projects are in line national development priorities.

Research, data, knowledge and information management

Overview

Research has played important role in supporting agricultural development and transformation in the country. Investment in the development and dissemination of new scientific evidence and technologies is the primary driver of agricultural productivity growth. Kenya Agricultural and Livestock Research Organization (KALRO) and the Kenya Marine and Fisheries Research Institute (KMFRI) are the country's leading public agricultural research and development (R&D) institutions. The universities such as the University of Nairobi (UoN), Egerton University, Jomo Kenyatta University of Agriculture and Technology (JKUAT) and Kenyatta University (KU) all have very strong agricultural research orientation. However, the key challenge has been the weak linkage between the research system and the end-users of the outputs of research i.e. the technologies and innovations. The deployment and diffusion of technologies and innovations from the research system is low for various reasons including lack of awareness of these outputs and inability to afford them.

Agricultural research in the country has generated important datasets. These datasets include information on rural farming such as crop varieties, acreage cultivated, number and types of livestock, farmer household data, productivity levels, agricultural technologies adopted and adapted and farming systems among others (Faostats, 2020). The agricultural advisory services, extension and outreach has evolved from a top-down and coercive arrangement from the early colonial period to the present bottom-up, demand driven system. To address the challenge posed by climate change, KALRO has established - The Agro-Weather Tool - a web and mobile-based information system that incorporates climate information and good agricultural practices for farmers. The tool has been developed to help farmers better manage weather risks, maximize productivity and minimize the environmental impact of farming practices.

Agriculture research, data, knowledge and information management

Agricultural research and innovations

Agricultural research has a direct benefit to the majority of smallholder farmers as it improves productivity and livelihoods. In Kenya, agricultural research is supported by Government as well as development partners. Increasingly, the private sector is involved in supporting agricultural research especially in release of new crop varieties. The primary public sector agricultural research institutions are KALRO and KMFRI. They are complemented by other public research institutions such as the Kenya Industrial Research Institute (KIRDI) and Kenya Forestry Research Institute (KEFRI) and universities, especially University of Nairobi, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Egerton University and KU. There are also several non-governmental development agencies that undertake agricultural research and scientific evidence development within the scope of agriculture in Kenya such as the CGIAR Centres, including The World Agroforestry Centre (ICRAF), Alliance of Biodiversity and CIAT and International Livestock Research Institute (ILRI).

The agricultural research spending has remained very low despite the increase in agriculture sector spending. For instance, in 2000, the spending in agriculture were more or less at equal level (100) but between 2000-2004, the spending in research declined to 80; before starting to rise gradually to 2007, where it has remained stagnant up to 2015, then a decline in 2016 (Figure 6.1).

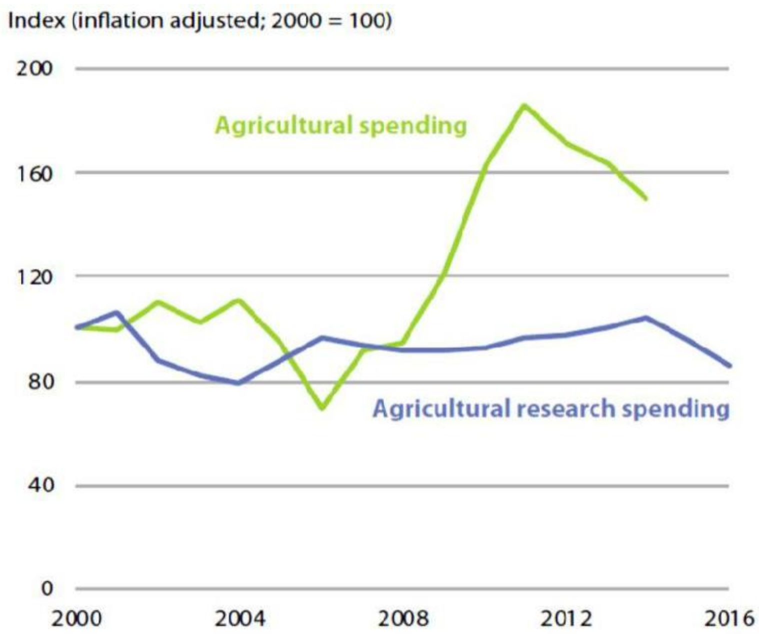


Figure 6.1. Agriculture research spending as percentage of the Agriculture sector budget.

Source: Beintema et al., 2018.

The government spending on agricultural research as a proportion of GDP has fallen steadily over the past decade. By 2016, it was 0.48%, approximately one-third of its value in 2006 and well below the African Union target of 1% (Beintema *et al.,* 2018; Birch, 2018). This is further compounded by lack of skilled manpower in the agriculture sector to deliver on the sector goals and objective. The government froze the hiring in the civil service in the 1990s, yet a large proportion of senior researchers approach retirement age and some have quit service for greener pastures, will exacerbate these capacity challenges (Beintema *et al.,* 2018). For instance, in 2018, Kenya had only 1,158 full-time equivalent agricultural researchers, compared to almost a third of the 3,025 experts that Ethiopia had within the same period (Birch, 2018).

Innovations in agricultural research

Some of the innovations in agriculture research are described below.

Digital innovation is creating unprecedented opportunities for Kenya to grow its economy. Gritech innovations include: precision agriculture, internet-of-things, drones, crop and soil sensing, weed sensing, disease sensing and *fintech* solutions. Through the *One Million Farmer Initiative,* the World Bank Group and its partners will harness the power of innovation in Kenya to vastly improve food security and farmer incomes. The three critical categories of agricultural innovation includes:

Category 1: Productivity

Enhances agricultural productivity and some examples are:

- *DigiCow*, a simple record keeping App for dairy farmers to enable them to increase their profits through data-driven decision making;
- Digital Green, which uses a video-enabled approach to reach large numbers of smallholder farmers with agricultural extension advisory services in an adaptable, scalable and cost-effective way;
- Farmers Pride, which combines franchise model, technology and village youth agents to bridge inputs, services and information gap among rural smallholder farmers;
- Precision Agriculture for Development, which reaches farmers with personalized agricultural advice through their mobile phones.

Category 2: Market linkages

These are innovation that promotes market linkages with the relevant actors in the value chain. some examples include:

- *M-Shamba*, a digital extension platform that uses interactive voice response services to transfer technologies to smallholder farmers
- *TruTrade* Africa, which uses cloud-based mobile and online applications to provide smallholder farmers with a reliable route to market and fair prices for their produce
- *Tulaa,* which use mobile technology and artificial intelligence to provide smallholder farmers with quality agricultural inputs on credit and broker the sale of their crop at harvest time.

- *SunCulture,* which develops and offers solar-powered smart irrigation systems

Category 3: Financial inclusion

The digital innovations in promoting the financing of the agriculture include:

- *ACRE Africa,* which links farmers to crop, livestock and index insurance. products to shield them against unpredictable weather conditions.
- *Agri-Wallet,* which provides mobile cash transfers for agri-buyers and farmers.
- *Arifu,* a personal learning tool you can chat with on any mobile device to learn new skills and access opportunities.

Agricultural data and statistics

Over the years, agricultural research in Kenya has generated important datasets through various programs and research activities. These datasets include information on rural farming such as crop varieties, acreage cultivated, faced challenges, number and types of livestock; farmer household data; productivity levels; agricultural technologies adopted and adapted; farming systems among others (FAO). MOAL&F and state departments and agencies. The data available at the MOAL&F include livestock numbers, annual crops production volumes and values, monthly cash crop (coffee, tea, export and import values imports volumes, values and prices; Monthly commodity export data. In livestock and fisheries, the data available is on annual livestock and fisheries production volumes and values including unit prices, Monthly formal milk production volumes and values and annual capture fish volumes and values. *Kilimo* dataset (http://www.kilimo.go.ke/dataset/).

The sources of agricultural data include:

- International organisations: these include United Nations Food and Agriculture organizations, World Bank, International Livestock research Institute, ICRAF, UNEP, UNDP, WFP, FAO etc.
- National organisations namely, Kenya Bureau of standards, MOALF&C, State Departments and Agencies, KIPPRA, research and academic institutions,

Some of the challenges with the agriculture data include:

- The data is scattered across the different institutions and quite often not easily accessible due to institutional bureaucracy. For example, the Ministry of Agriculture, Livestock, Fisheries and Cooperatives is one of the Global Open Data for Agriculture and Nutrition (GODAN) partners among the 15 national agricultural ministries and have signed a Nairobi Declaration in June 2017 on Open Data Policy in agriculture and nutrition as part of its commitment to the Sustainable Development Goals (SDG's). This partnership recognizes the fundamental role of Open Data in agricultural transformation by making data available, accessible and useful to smallholders and farmers. This will provide farmers with insight and tools to improve productivity and profitability. This only exists on paper but its practical implementation is yet to be achieved.
- The data collected are not consistent and subject to fund availability, thus has many gaps, since they are collected within the frameworks of projects that have a lifespan of less than 5 years. This makes the use of the data with extrapolations that may not reflect the true situation on the ground
- Different institutions use of different approaches and methodologies in generating the data, thus the challenge of comparability and scalability.

Weak infrastructure and limited capacity of the agriculture experts to generate the required data to inform the policy processes. For example, in MRV, Kenya have a weakness in terms of capacity in the areas of quantification and verification, which require experts to conduct experimental exercises in order to establish the inventory factor, especially in livestock remains critical in making the estimate, quite often, where data is not available IPCC default values are used which may not reflect the real situations. Unfortunately, the national experts have weak capacity to effectively lead the MRV processes especially in KALRO and academic institutions, the research institution in charge of developing the MRV system.

Knowledge and information management

In Kenya, Agriculture knowledge and information is available from different institutions at county, national, regional and international levels. The information is available inform of published and unpublished reports available in the institution websites and e-platforms. Most of the data from international sources such as Faostats, World Bank are open access. However, the national data sources are available at a cost. Also, there is no centralized system for knowledge and information management across different stakeholders ranging from academia, government ministries, Non-governmental organisations and international organisations such as World Bank and Food and agriculture Organisations. The different knowledge and information is available in the different institutions websites, making it difficult to know what each of the institutions are working on. Therefore, the information is disjointed. Currently, the MOAL&F is coordinating a multi-stakeholder platform to share knowledge and information across the different institutions to consolidate the knowledge and information available.

Climate information systems (CISs)

Climate information and early warning systems provide useful inputs into the agricultural sector and assists farmers in making decisions. Weather-related factors already form the biggest risk to agricultural productivity in Kenya. Thus, CIS include immediate and short-term weather forecasts and advisories and longer-term information. CIS is especially useful in helping farmers to manage risks in their agricultural production practices, thus helping them to adapt to climate variability and change (Ngari *et al.,* 2016). Much of this information should be adapted for use in local conditions.

The CISs in Kenya are mainly provided by government agencies, international organisations, research and academia, community-based organisations and non-governmental organisations (CBOs and NGOs). The Kenya Meteorological Department (KMD) is the national meteorological agency mandated to collect and store national climate data and manage the climate information provision framework. The CISs is provided through newspapers, bulletins, radio, television, trained personnel/intermediaries, short media messages (SMS) and internet

(Muema, 2018). The use of radios has been found as the most common channels for disseminating CISs among smallholder farmers in Kenya as it is easily accessible and reaches to wider population through the use of vernacular languages. The use of mobile phone through SMS is also strongly preferred by the farmers (Hampson *et al.,* 2015). Most CISs providers are working in direct partnership with KMD in co-generating climate information service/product or indirectly use data produced by KMD.

While it remains the mandate of the KMD to provide accurate and timely meteorological information and services, recent studies have established that the private sector are leading in providing the CISs, followed by government agencies, then non-government organizations (NGOs) and community based organizations (CBOs). Other players in the providing CISs in the country include research institutes and the academia (World Banks 2016; Muema, 2018).

Main categories of climate information provided in Kenya

Daily weather forecasts – outlines predictions on temperature and rainfall variability to farmers daily.

Decadal agro-meteorological bulletins – provides climatic statistics on temperature, precipitation, relative humidity and wind for the last 10 days countrywide.

Monthly climate outlook – reports temperature and precipitation variability for every climatological zone on a monthly basis.

Seasonal climate outlook – gives climate information on various rainfall seasons in a year. Comprises prediction on expected temperature, rainfall onset and cessation dates and the distribution throughout the season.

Climate alerts – offered on need basis and may include timely information on weather extremes such as drought, floods and associated disasters.

Tailored information for users – provides climate information on onset, cessation and distribution of rainfall together with advice on choice of crops for different regions.

Source: Muema (2018)

The KALRO has established - The Agro-Weather Tool - a web and mobile-based information system that incorporates climate information and good agricultural practices for farmers. The tool has been developed to help farmers better manage weather risks, maximize productivity and minimize the environmental impact of farming practices. Alongside the formal information through the CISs, local farmers also rely on their own indigenous seasonal forecasts, which are mainly based on natural indicators such as clouds, moons, starts, behaviour of animals, and insects, flowering and shedding f leaves and the direction and strength of wind (Kagunyu, 2016).

Agricultural advisory services, extension and outreach

Agricultural advisory services, extension and outreach can be described as systems and mechanisms designed to build and strengthen the capacity of rural farmers and other stakeholders (GoK, 2017). They are accomplished by not only providing access to information and technologies but also by enhancing agricultural skills and practices, capacity to innovate, and address varied rural development challenges through training programs, improved management and organizational techniques (Mbo'o-Tchouawou and Colverson, 2014). They play critical role in facilitating linkages with farmer-based organizations and other relevant actors (such as government agencies, private sector and non-governmental organizations (NGOs), research institutes and education centres. These services also contribute to agricultural sustainability, livelihood improvement and well-being of populations in rural setups (Mbo'o-Tchouawou and Colverson, 2014).

The National Agricultural Sector Extension Policy (NASEP) spells out modalities for effective management and organization of agricultural extension in a pluralistic system where both public and private service providers are active participants. The new policy provides a framework for service providers and other stakeholders on standards, ethics and approaches, and guides all players on how to strengthen coordination, partnership and collaboration. In this regard, effective agricultural extension and advisory services should: be client-driven to respond to targeted potential clients needs while maintaining professional standards; be relevant; be coordinated to harness synergy and prevent negative impact on the welfare of clients; avoid duplication of efforts and working at cross-purposes; ensure equity in covering all categories of clients including vulnerable groups; have sound governance; have effective mechanisms for monitoring, evaluation & learning; ensure human and social capital development; be participatory; be sustainable in terms of productivity, risk reduction, protection of the environment, economic viability, social acceptability and technical and commercial feasibility; ensure corporate governance and; be priority focused guided by National and County government strategic priorities, policies and legislation (GoK, 2017).

Kenya government has over the years employed various extension approaches such as progressive farmer model (where other farmers would learn and benchmark against the progressive farmer), Training and Visit (T&V), and Farmer Field Schools (FFS) among others (Kavita, 2018). Other than the FFS which is still being practiced for field demonstration purposes, the other two are no longer common. The farmer Common Interest Groups (CIGs) model where advisory services are given to the groups on demand has been embraced in the country. The ratio of extension officers to farmers in Kenya stands at 1:1800, far below the FAO recommendation of 1:400 (Mwaniki et al., 2017). The low extension: farmer ratio makes it difficult for agricultural extension personnel to give personalized advisory service to individual farmers thus justifying the CIGs (Kavita, 2018). Other currently adopted extension approaches in the country include on-farm demonstrations, shows, field days, film shows, adaptive on-farm trials, and mobile training units (GoK, 2012).

The entry of non state actors has helped fill the gap of low number of public extension officers. . Currently, extension and advisory services are provided through either or a mixture of three different models:

- *Model 1:* offers free public extension and advisory services mostly to smallholder farmers engaged in growing staple foods and minor cash crops across all the agro-ecological zones
- *Model 2:* partial cost-shared provision of extension and advisory services, mostly within the public sector where limited commercialization has taken place

- *Model 3:* fully commercialized and mostly involving the private (e.g. private companies and cooperatives) and quasi-public organizations mainly for specific commodities such as tea, coffee, sugar, pyrethrum, barley, tobacco, horticulture and dairy. Under this system, extension and advisory services are usually embedded in agricultural services.

The ministry has developed guidelines and standards for extension and advisory services to steer the agricultural sector in the provision of coordinated, effective and efficient extension and advisory services (GoK, 2017). Unfortunately, all the extension models are not farmer-centred as they t and are based top-down based and supply driven thus paying giving little attention to the farmer and the needs of women and youth.

Governance and performance measurements

Overview

The Constitution of Kenya establishes two levels of government: National and 47 County Governments. Under the Fourth Schedule, the Constitution delineates functions to be performed by the National and the County Governments (Table 7.1). Agriculture is one of the functions that is fully devolved to the County Governments with the National Government being responsible for agricultural policy and research.

Table 7.1. Distribution of functions in Agricultural sector between national and county governments as set out in the Fourth Schedule of the Constitution.

National Government	County Government
Agricultural Policy Veterinary Policy (including regulation of the profession) **Related Sectors** Protection of environment and natural resources including fishing, hunting and gathering, protection of animals and wildlife,	Crop and animal husbandry Livestock sale yards County abattoirs Plant and animal disease control Veterinary services (excluding the regulation of the profession) Animal control and welfare; and fisheries

water protection, securing sufficient residual water, and safety of dams.	**Related Sectors** Trade development and regulation including markets, fair trading practices, and cooperative societies Certain aspects of natural resources and environmental conservation including soil and water conservation, and forestry Water services including storm water conservation (damming, etc.)

Source: Modified from Muriu and Biwott(2014).

The National Government through the Ministry of Agriculture, Livestock, Fisheries and Cooperatives (MOALF&C) has put in place several agricultural policies to support implementation of agricultural development and initiatives by the County Governments. The County Governments through the County Integrated Development Plans (CIDPs) identify priority action areas in the agriculture sector for which budget is allocated.To enhance coordination between the two levels of Governments, several structures have been established to support and enable effective engagement and coordination between the national and county governments.

Governance of the agriculture sector

National level

At the national level, the Ministry of Agriculture, Livestock, Fisheries and Cooperatives (MOALF&C) provides the overall leadership for the agriculture sector in the country (Figure 7.1). Key functions of the ministry include: agricultural policy formulation and monitoring its implementation; agricultural research and promoting technology delivery; regulating and quality control of inputs, produce and products from the agricultural sector; collecting, maintaining and managing information on agricultural sector; and management and control of pests and diseases. The Ministry has three core departments: (1) State Department for Crop Development and Agricultural Research, (2) State Department for Livestock and (3) State Department for Fisheries, Aquaculture and Blue Economy. Each of these departments has a number of directorates.

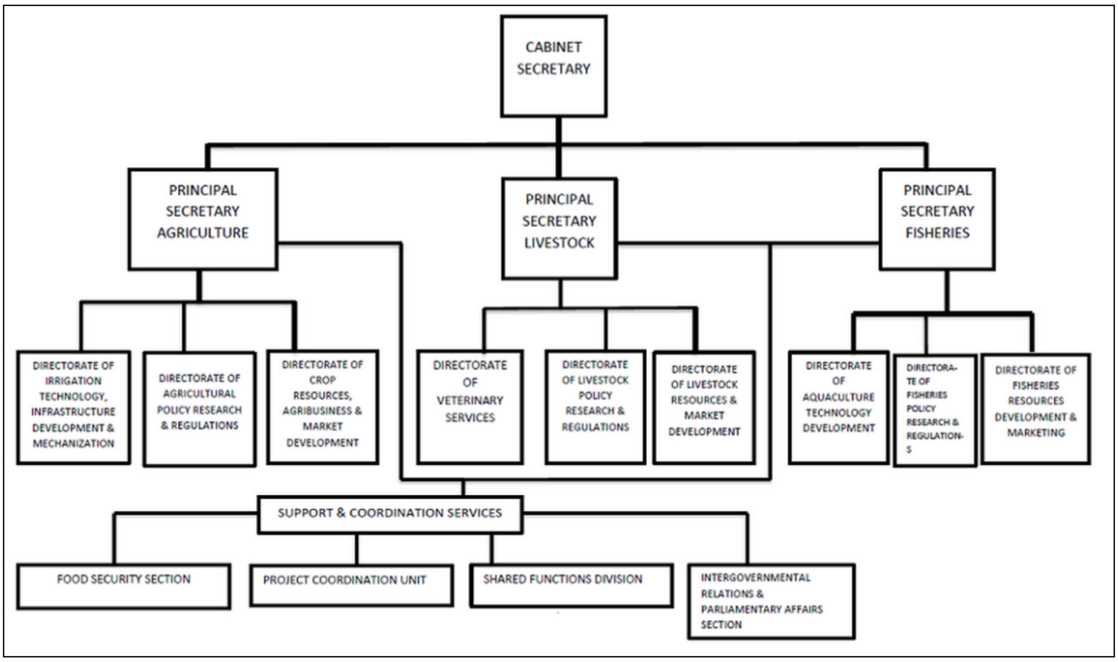


Figure 7.1. Indicates the institutional organization of the MoALF&C.

Source: JASSCOM (2017)

The devolution of the agriculture comes with significant changes and implications on both horizontal and vertical sector coordination. This has necessitated internal institutional restructuring and reforms within the ministry to ensure that her structures and policies are aligned to the Constitution with mechanisms for consultation and coordination with county governments. However, several challenges are still being experienced with the most critical ones being weak linkages and coordination between the national and county levels and among the counties themselves, slow and weak communication due to increased bureaucracy, lack of synergies between counties and slow legislation of county laws to enhance implementation of the agricultural policies.

To address the challenge of weak coordination between the two levels of government, the following mechanisms have been established:

- *Inter-Governmental Summit (IGRS):* The Summit provides overall political direction to the agricultural and other sectors. It is a meeting between the President and the Governors of the 47 Counties. supported by the Intergovernmental Relations Technical Committee (IGRTC).

- *Intergovernmental Relations Technical Committee (IGRTC):* Provides the framework for consultation and co-operation between the National and County Governments and amongst county governments, including on matters agriculture sector. It serves as the secretariat of the IGRS (Figure 7.2).
- *Inter-Governmental Forum for the Agricultural Sector (IGF):* The Forum is Co-chaired by the Cabinet Secretary, MoALF&C and the Chair of the Council of Governors. The IGF is mandated to ensure overall sectoral consultation between the two levels of government. They meet on a yearly basis to resolve sector issues affecting both levels of government. Other sector stakeholder, including members of the Agriculture and Rural Development Donor Group, may join special sessions of the IGF.
- *Joint Agriculture Sector Steering Committee (JASSCOM):* The JASSCOM is a platform for regular sector steering meetings between high-level national and county decision-makers. Other sector stakeholder, including the leadership-Troika of the Agriculture and Rural Development Donor Group may join special sessions of the JASSCOM.
- *Joint Agriculture Sector Technical Working Groups (JAS_TWG):* The four Intergovernmental Thematic Working Groups established under the MoALF Transformation Initiative have been replaced by four JAS-TWGs. Each JAS-TWG comprises of 3 members appointed by the CS–MoALF&C, 3 appointed by the Council of Governors (CoG) and a member from the Joint Agriculture Secretariat. Other sector stakeholders may be invited to joint JAS-TWG meetings.
- *Joint Agricultural Secretariat (JAS):* The JAS provides secretariat function for the IGF, JASSCOM and the JAS-TWGs. It prepares for the IGF consultations and implements its resolutions. The JAS also houses the sector M&E node.

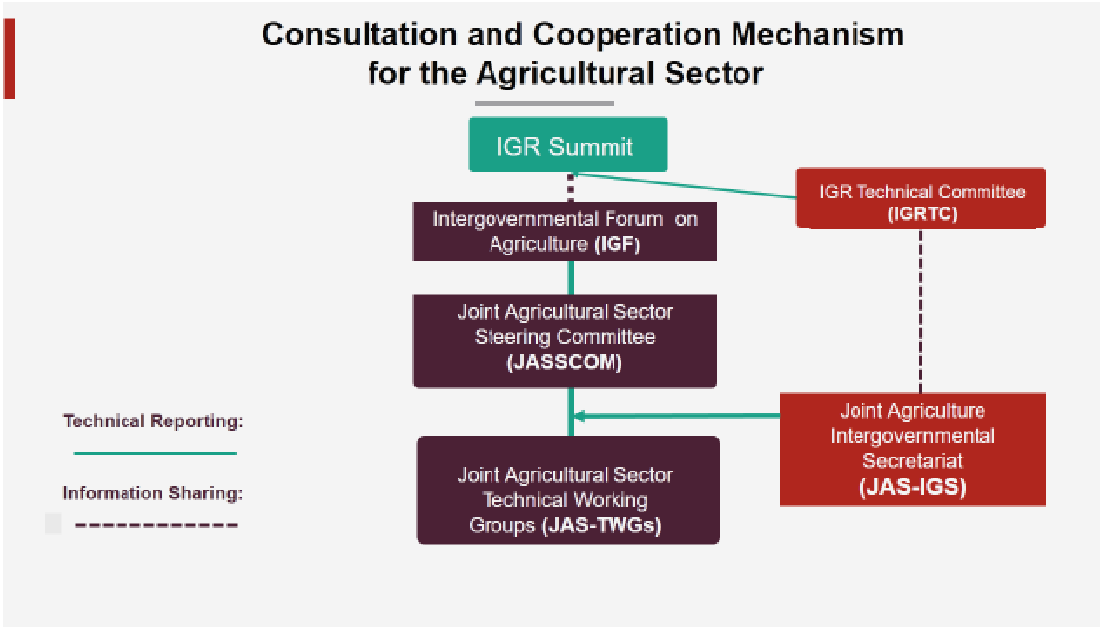


Figure 7.2. Consultation and cooperation mechanism for the Agricultural Sector (Agricultural Sector Development Support Programme II(2017)

County and sub-county level

The county governments are responsible for implementation of agriculture policies and legal frameworks. In this regard, the counties have established institutional structures and systems to support implementation of various agriculture sector policies and development plans, including at the local levels. These include: County Executive Committee (Agriculture); County Chief Officer (Agriculture); County Directors (Agriculture); Sub County Officers and Ward Extension Officers (Figure 7.3).

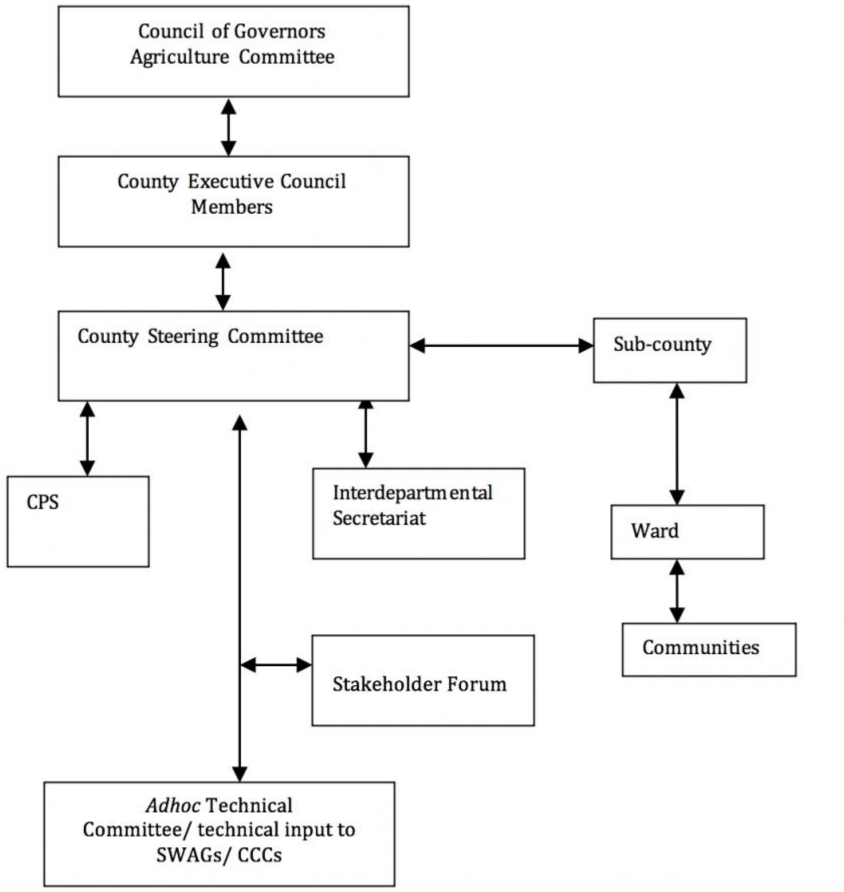


Figure 7.3. Agriculture sector structure at county level.

Performance measurements

Monitoring and Evaluation (M&E)

The Government of Kenya operationalized the National Monitoring and Evaluation Policy in 2012 in efforts to strengthen government's commitment to transparency and accountability for development results; establish mechanisms and strategies for measuring efficiency and effectiveness of public policies, development plans, programmes and projects and; provide channels for effective policy implementation feedback hence efficient allocation of resources. This allows for a transparent process and a common for stakeholders to undertake a shared appraisal of results; and outlines the principles for a strong M&E system as instrument for tracking progress on programmes on Kenya Vision 2030 (GOK, 2012).In support, directorate was established under Ministry of Planning and Finance to support the National Integrated Monitoring and Evaluation System (NIMES).Currently, the Treasury and

Ministry of planning have seconded M&E Desk Officers in each of the ministries to help in the implementation of NIMES.

At the MOALF&C, the planning unit has indicators that are used to report against medium term plans (MTPs). The agriculture does not have a sector M&E framework to track implementation and impacts of the agricultural policy. M&E in the sector appears to be programme/project based making it difficult to harmonize M&E reporting systems. The ministry needs to develop an agricultural sector M&E Framework that would be used regularly and transparently to assess the implementation of the agricultural policy, sector investments and sector performance. Such sector M&E results would be used to make necessary adjustments for better performance and improved outcomes for the sector and to feed into the NIMES. At the devolved government level, only a few counties have monitoring and evaluation units at the sector level to monitor and evaluate progress of sector plans due to inadequate capacity at the counties among other challenges.

Measurement, Reporting and Verification (MRV)

The National Performance and Benefit Measurement Framework (NPBMF) or MRV+ has been developed. It is an integrated framework for monitoring, evaluating and reporting progress on mitigation and adaptation actions, and to create synergies between them. The intention is to link the MRV+ system to the National Integrated Monitoring and Evaluation System (NIMES) and the County Integrated Monitoring and Evaluation System (CIMES) (GoK, 2016). At the National level the government is in the process of expanding the scope of NIMES, Counties are also in the process of putting in place the CIMES.

To operationalize the NPBMF, the following actions have been proposed:

- Finalising the institutional set-up for coordination of the national MRV activities at the Climate Change Directorate, as required by Kenya's Climate Change Act (2016).
- Conducting awareness creation and training activities for key stakeholders in government and the public sector, civil society and the private sector, with a

special focus on devolved county governments where a significant proportion of climate action is expected to take place.

- Developing a common framework for tracking and reporting on climate action at the national, county and sectoral levels, and for ensuring alignment with the NDC.
- Establishing formal data collection and sharing arrangements, including Memorandums of Understanding (MoUs), between data suppliers and users, and ensuring adequate quality assurance and control of the data.
- Providing adequate budgetary allocation for MRV activities.
- Establishing climate action (mitigation and adaptation) registries and systems for the coordination of climate action, and for assessing and tracking the effectiveness of the actions, together with climate finance that has been allocated to them.

Transformation agenda: Towards low carbon, climate resilient development

Overview

The agriculture sector is a major driver of growth for the Kenyan economy and a dominant source of employment for roughly half of the Kenyan people. The sector is pivotal for the country to achieve the formidable goals established in the government's Vision 2030, which are to transform Kenya into a globally competitive, prosperous country with a high quality of life by 2030. Both macroeconomic and agriculture policies recognize agriculture as a primary source of growth in the country. They also recognize the value women and youth who are the majority of the population could bring to agricultural transformation. The country has great potential to increase crop production through yield increases because farm level yields are several times below what is obtained at research stations. The yields of almost all the food crops are significantly below the on research station yields. Areas that have potential of catalyzing agricultural growth include: use of improved inputs including seed, stocking and planting materials; adoption of sustainable land water management practices and ICT. Agricultural growth is needed to leverage rapid growth in the larger agri-food system, including agro-processing and trade.

Agricultural growth potential and sources of growth

To realize agriculture's potential, there is need to overcome a range of challenges in relation to agricultural productivity and the sector's vulnerability to climate risks. Achieving agriculture productivity growth and resilience will require better technology and sound land management practices, as well as the dissemination of knowledge on sustainable input use through effective extension services. There are several opportunities that can be explored to increase growth in the agriculture sector. These include:

- *Low agricultural productivity:* Large gaps exist between current crop yields and attainable yields that need to be addressed to improve productivity and enhance farmers' incomes and livelihoods.
- *Access to credit:* The sector suffers from low levels of credit and financing and commensurately sub-optimal levels of investment. Many farmers are often hindered in the purchase of productivity-enhancing inputs (e.g., seed, fertilizer, pesticides etc.) due to limited access to finance. One potential area that could help ease the situation is full implementation of the warehouse receipts system that would allow farmers to use receipts as collateral. Also, improving the use of crop and livestock insurance as collateral could enhance access to agricultural credit.
- *Low public investment:* Despite the role of the agriculture in the country's economy, the budgetary allocation for the agriculture sector has remained relatively low (less than 5%) in the wake of an ever-increasing national government budgets. Increasing the public spending in agriculture as per the Maputo declaration to spur agriculture growth by 10%will enhance investments and transformation of agricultural systems in the country.
- *Leveraging innovations in the information communication technology (ICT):* Kenya is ahead of the curve on ICT innovations. There is a clear will and capacity of entrepreneurs in Kenya for market-based innovation and adoption of agro-

based technologies that could enhance farmer access to information and boost productivity and farmer incomes.

- *Agricultural value addition:* Vast market potentials in the entire food systems, especially for agro-processed and value added agricultural products, thus opportunities for strengthening agribusiness practices at various levels including; farming, seed and feed supply, agrichemicals, farm machinery, wholesale and distribution, processing, marketing, retail sales, and exports.
- *Irrigation:* remains a key enabler for building resilience and climate proofing the sector. Returns to public spending on smallholder irrigation schemes could be significant. There is need to boost investment in small holder irrigation schemes and to promote private sector investment in irrigation.

Indicative priority adaptation and mitigation action areas

Well targeted investments in the agriculture sector are capable of uniquely deliver mitigation and adaptation benefits as well as economic, environmental and social co-benefits. In this regard, the following priority adaptation and mitigation action areas are proposed as shown in Table 8.1.

Table 8.1. Indicative priority adaptation and mitigation action areas

Adaptation priority action area	Mitigation Priority areas
Increase adoption of Sustainable Land Management	Agroforestry
Increase access to climate-related resilience and safety net programmes	Manure management to reduce the GHG emissions. i.e. biogas plants etc
Increase on- rainwater harvesting and storage, to expand land under irrigation.	Reduction in the number of livestock species to minimize overgrazing that exposes soils to degradation and release of carbon in the atmosphere.
Expand the livelihood sources including the value addition f raw products along the value chain to increase the income levels	Livestock substitution, where cattle are substituted to camels because the enteric fermentation in camels is higher than cattle
Management of pre-and post harvest agricultural losses	Improved feeds and feed additives to reduce enteric fermentation
Gender and you integration in the CSA Programmes, Strengthen the adaptive capacity of the most Vulnerable groups and communities	Enhanced use of efficient energy technologies in the processing along the value chain. renewable energies

- Cascading CSA programmes and policies at county level
- Strengthen the relevance of platforms for sharing of up- to-date data and information on agriculture and nutrition among stakeholders
- Implement agroforestry , afforestation and re-fforestation programmes at county level
- Limiting the use of fire in range and cropland management involves reducing the frequency and extent of fires and/or reducing the fuel load through vegetation management and burning at times of year when fewer GHGs are emitted from burning
- Conservation tillage or zero tillage
- Strengthening the engagement on the Multi-stakeholder platform
- Strengthen the technical and financial capacities of experts to respond to emerging climate change needs in agriculture sector
- Comprehensive M&E and MRV frameworks for tracking progress in adaptation and mitigation.

Source: Modified from the Mitigation Analysis Report (2017)

Finance and investments in the agriculture sector

Overview

Financing and investment are critical for development and transformation of the agriculture sector. Public financing remains the primary source of financing for the sector in the country. Despite the role of the agriculture in the country's economy, the budgetary allocation for the agriculture sector has remained relatively low and constant in the wake of an ever-increasing national government budgets. While the total budgetary allocation for the agriculture indicated an increasing trend in the recent years, it remains below 5% over the past one and a half decades despite the rhetoric on the importance of agriculture in the economic growth and transformation in the country. The sector continues to experience low productivity, poor access to productive assets and weak commercialization, which have been characterized by minimal use of technologies and low public investments and financing over the years. It generally accepted that overseas development assistance (ODA) flows into the agriculture sector has been on decline and now much of the investment will need to come from the private sector.

Public expenditure through the national budget

The Kenya national budget has shown an increasing trend in the last 19 years from KES 217.2 billion in 2000 to KES 3.2 trillion in 2019 (Figure 9.1). While the national public budget has continued to show an increasing trend in the recent years the public spending in the agriculture sector has remained highly varied but relatively low since the year 2000 (Figure 9.1 and data on Annex 1).

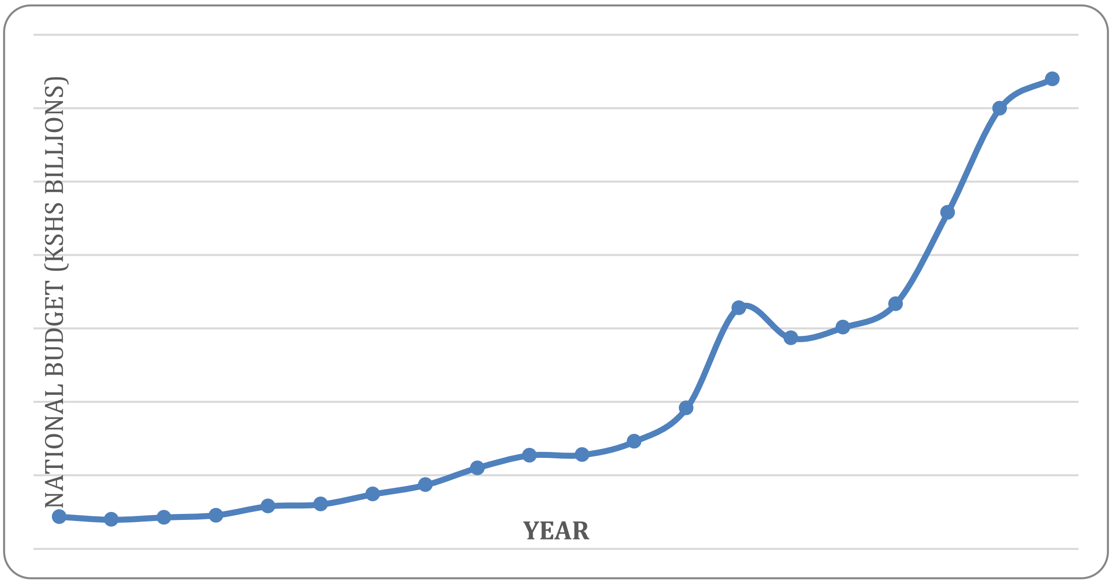


Figure 9.1. Kenya national expenditure, 2000-2019.

From the year 2000 to 2005, the public spending in the sector showed an upward trend from KES 7.19 billion to KES 10.85 billion. The declining trends were noted in the year 2006/07 (8.6% the 2005/2006 value of KES 10.85 billon) and the Year 2013/2014 with a decline of 24.6% from the 2012/2013 value of KES 1641 billion. The highest budget increase of 83.3% was noted in the year 2013/2014 from the 2012/2013 values. The sectors' budget was highest in the year 2016/2017, with a KES 69.9 billion budget allocation, followed by KES 52 billion in the year 2019/2020.

The AU's Malabo Declaration set forth a series of concrete development goals to be reached by 2025, including achieving a 6% annual agricultural growth rate and a 10% agricultural expenditure share. The data obtained from KNBS (2010-2019) and Kenya Budget guide 2000-2019 shows that for the period 2000 to 2019, the government spending on agriculture sector has remained very low and has not met the commitment under Maputo Declaration. For example, in the ten-year period (2000 to 2010), the average public spending on agriculture sector as %age of the national budget ranged between 2.7-5.0% with an average of 3.8%, with the highest at5.0%being reported in the 2002/2003 and the lowest in the year 2006/2007 at 2.7% (Figure 9.2 and 9.3).For the period 2011 to 2019, the agriculture public spending as a percentage of the national budget was on average at 3.3% with the highest percentage of 4.8% reported in the year 2019/2020 and the lowest at 2.3% being reported in the years 2013/2014 and 2017/2018.

The agricultural expenditures as a share of total government expenditures remains below less than 5% which still falls short of the recommended 10% target to accelerate the 6% agricultural growth rate. However, in the year 2017 reporting period, other areas of progress achieved by Kenya includes: about 100% completion to the CAADP process; about 75% of the farmers had access to agriculture advisory services; about 83% of men and women engaged in agriculture had access to financial services; approximately 281% increase of the size of the irrigated areas from the values of the year 2000 and lastly 18% of the youth engaged in new job opportunities in agriculture value chains.

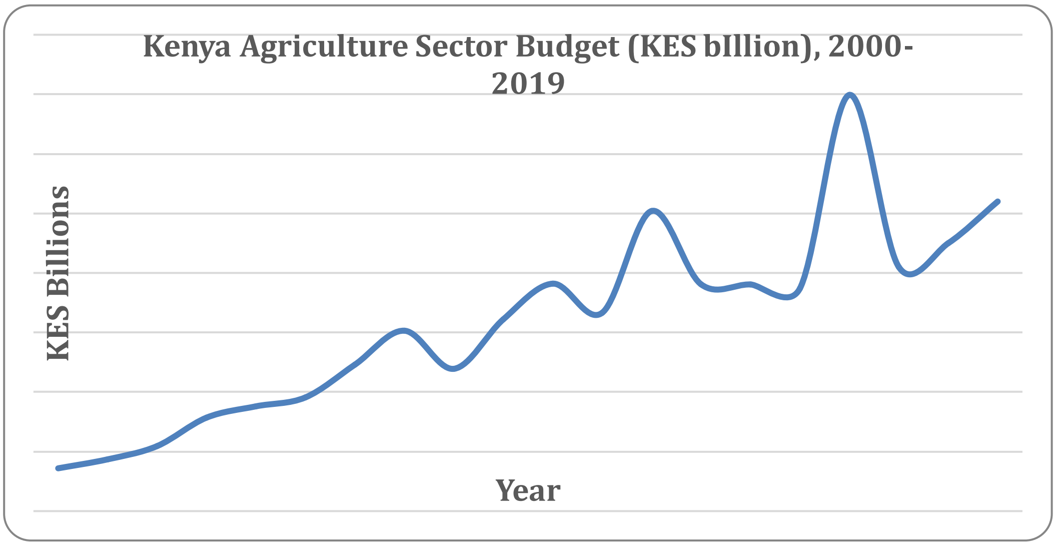


Figure 9.2. Agriculture sector budget allocation for the period 2000 to 2019.

Source of data: KNBS (2010-2009); Kenya Budget guide 2000-2019; Maina, 2013; Faostats (2001-2011)

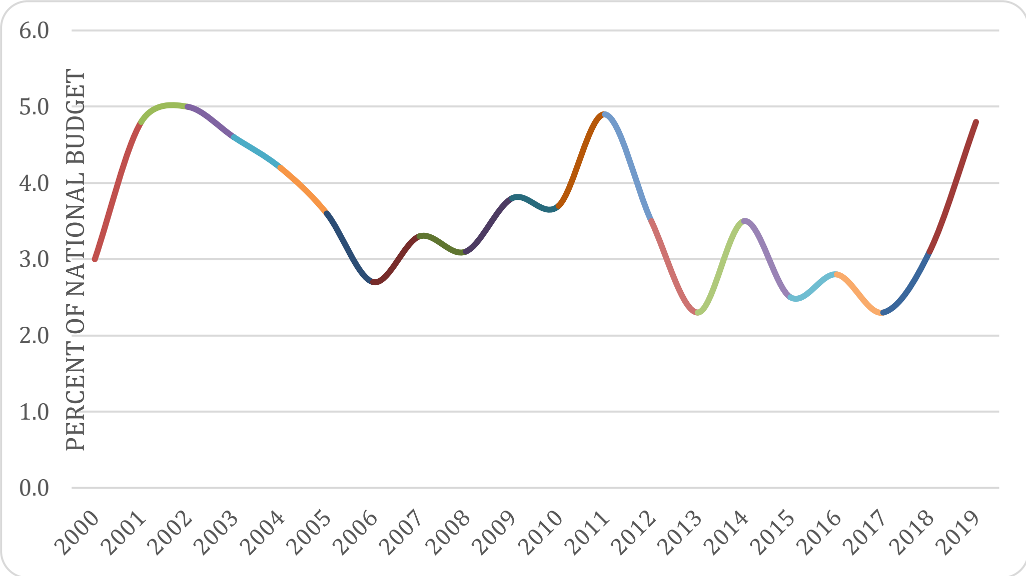


Figure 9.3. Kenya agriculture sector expenditure as % age of the national expenditure.

The public sector investment is complemented by the Agricultural Finance Corporation (AFC) - a Government Development Finance Institution (DFI) - that provides credit/loan for the sole purpose of developing agriculture.

Regarding national credit, it has increased tremendously from KES 289.5 billion in 2000 to 2.5 trillion in 2018 (Figure 9.4). Similarly, the agricultural credit has increased by 146% from KES 25.4 billion in 2000 to KES 83 billion in 2018 (Figure 9.5).

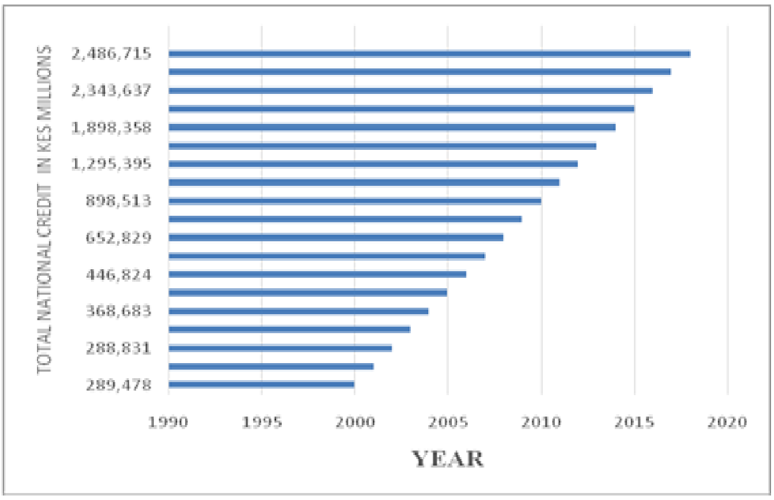


Figure 9.4. Total national credit in Kenya in KES millions.

Source: Faostats 2000-2018

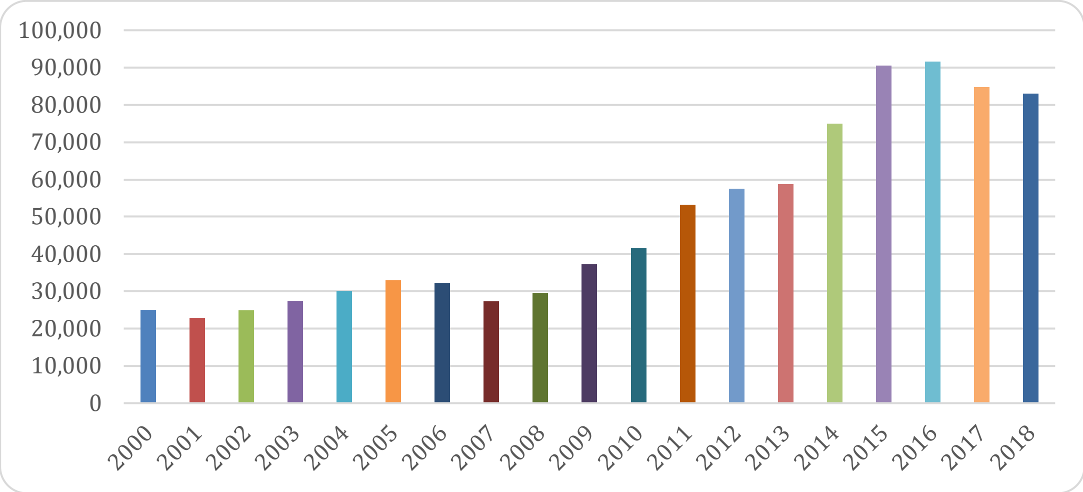


Figure 9.5. Total Agricultural sector credit in Kenya in KES millions.

Source. Faostats 2000-2018

The agriculture sector credit as a percent of the national credit has been on the decline since the year 2000, from 8.7% to 3.3% in 2018 with exception of the year 2003, when the value was 9.1% (Table 9.6), which is the period the National Rainbow Coalition (NARC) Government came into power and prioritized agriculture in its agenda. This changed slowly and priorities were shifted to the industrial sector with the objective of creating more jobs for the youths. Years 2008, 2014 and 2018, which were just years after national elections, also registered declines. The likely explanation is that the agricultural finance institutions often wait and see on the priorities of the new governments before availing financial resources to the farmers since politics plays an important role.

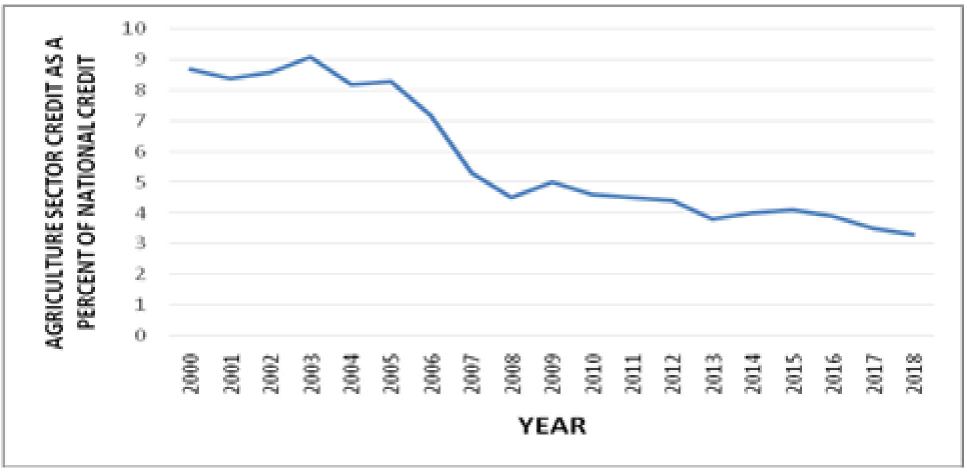


Figure 9.6. Agriculture sector credit as a percent of the national credit in Kenya.

Source. Faostats 2000-2018

Overseas Development Assistance (ODA) and Foreign Direct Investments

Overseas Development Assistance (ODA)

Kenya continues to receive a substantial overseas development assistance (ODA). Some of the most commonly areas supported and intervention include: strengthening food security and nutrition; safety nets; improving access to farm inputs; agricultural advisory services; agri-business development; improving natural resources management and technical capacity development (FAO, 2015).

The International Finance for Agricultural Development (IFAD) alongside other partners including AGRA and Equity Bank developed a cheap credit facility, *Kilimo Biashara*, which provides credit facilities to farmers, agro-dealers and agro-processors especially in the dairy sector and cereal value chains.In the past, IFAD activities concentrated on rural areas with medium to high productive potential, where most of Kenya's rural people live. However, support has now been extended to the country's arid and semi-arid regions. This shift supports the government's commitment to improve small-scale irrigation, extension services, marketing and access to financial services in areas with high poverty rates. The emphasis is on a market-oriented approach in the sectors of horticulture, dairy production, cereal commodities and rural finance.

The United States Agency for International development (USAID) through the Feed the Future initiative supports smallholder households in the country to address the root causes of poverty and hunger by disseminating modern farming practices with a focus on four main value chains: dairy, livestock, horticulture and staple foods.The Kenyan agricultural sector also receives support from NIRAS Development Consulting Agency, funded by the development cooperation agency of Sweden (*SIDA*). NIRAS provided technical support to the first phase of the Agricultural Sector Development Support Programme (ASDSP I), a large-scale project covering all 47 counties of Kenya and designed to help commercialize the sector, lifting incomes and reducing food insecurity for value chain actors. Due to the success of the first phase, the second phase of the ASDSP has been approved with joint funding from *Sida,* Government of Kenya and the European Union. In ASDSP II (2019- 2022), emphasis is placed on overcoming challenges associated with poor access to markets, high prices of agricultural inputs and general uncertainty that reduces investment in the sector in order to improve overall productivity.

Foreign Direct Investments

Kenya has also been identified to be one of the largest recipients of Foreign Direct Investment (FDI) in Africa, with the inflow of FDI increasing significantly since 2010. However, considering the size of the Kenyan economy and the level of development, these investments remain relatively low. The total FDI stock was at US$15.7 billion in 2019. Owing to the arrival of fiber optics in 2009-2010, a large proportion of FDI have been directed to the ICT sector. Other sectors targeted by FDI are banking, tourism, infrastructure and extractive industries. In the agriculture sector, notable growths were realised in the manufacture of grain mill products at 8.3%, bakery products at 8.1% and animal feeds at 8.6% (KNBS Economic survey, 2018). The main investors in Kenya include the United Kingdom, the Netherlands, Belgium, China and South Africa.

Table 9.1. FDI Investment in Kenya in comparison to Global FDI stock

Foreign Direct Investment (FDI)	2017	2018	2019
FDI Inward Flow (million USD)	1,266	1,626	1,332
FDI Stock (million USD)	12,874	14,410	15,742
Number of Green Investments	52	65	95

Source: UNCTAD, 2020

Private sector investments

Despite the critical role that the private sector plays in promoting agricultural transformation, their participation in the agriculture sector is comparatively low. For example, of the total budget required to operationalize the agriculture sector development strategy (ASDS) 2010-2020, private sector financing was just 2.41%. The sector has great potential to unlock vital finance and develop innovative solutions. Kenya has established systems to tap into the global green bond market which has grown tremendously in recent years. The Green bonds initiative was launched in Kenya in March 2017 to catalyse the market for green bonds and build on the Kenya Green Economy Strategy and implementation plan (GESIP) 2016-2030 which commits to invest US$ 23.5billion in Kenya's green growth path. Green bonds are regular bonds that generate proceeds that are exclusively earmarked for projects with environmental benefits. Issuances in Kenya's green bond market stood at US$155.5 billion in 2017 and an estimated US$250-300 billion in 2018. Kenya was the first country in East and Central Africa to issue a green bond which is being traded on the Nairobi Stock Exchange (NSE). The proceeds from the Green Bond will be reinvested in green projects. This is an initiative of the Central Bank of Kenya in partnership with Kenya Bankers Association (KBA), Nairobi Securities Exchange (NSE), Climate Bonds Initiative (CBI), Financial Sector Deepening (FSD) Africa and the Dutch Development Bank (FMO).

Climate finance

At present, there are inconsistencies between countries, regarding what they count as climate finance. This means that different national reports may not be comparable, complete or consistent. Given the challenges in classifying and determining what counts as climate finance under the United Nations Framework Convention on Climate Change (UNFCCC), the closest one can get is provided by the UNFCCC Standing Committee on Finance as:

"Finance that aims at reducing emissions, and enhancing sinks of greenhouse gases and aims at reducing vulnerability of, and maintaining and increasing the resilience of, human and ecological systems to negative climate change impacts." Other definition that is commonly used considers climate finance refers to "local, national or transnational financing – drawn from public, private and alternative sources of financing – that seeks to support mitigation and adaptation actions that will address climate change."

The broad nature of this definition demonstrates the diverse nature of the concept and the many different elements that need to be considered, include:

- the type of finance provided (development aid, private equity, loans or concessional finance);
- the source of the finance (is it from public or private sources);

- where the finance flows from [developed countries to developing countries, within developed or developing nations, developing to developed nations or from other sources such as multilateral development banks (MDBs)];
- if this finance is over and above what would have been provided anyway ("new and additional"); and
- what is ultimately financed (direct or indirect climate change related actions, or compensation for damages).

In general, the term 'climate finance' covers multilateral, bilateral and domestic financial flows relating to fixed capital investments contributing to either climate change mitigation or adaptation activities of both public and private sector. Whilst private sources include households, private companies, farmers and cooperatives, public funds include finance derived from national, regional or local government budgets or public financial institutions. Public finance covers direct infrastructure investments and financial incentives (policy-based finance) that leverage climate-related investments from the private and public sector.

Climate finance landscape is highly fragmented with finance to support climate action and to implement the Paris Agreement coming from multiple sources and is not always be labelled or clearly recognizable as climate finance. Finding the right source of finance is important as there is *'no one size fits all.'* The procedures for direct access places these funds beyond the immediate reach of many countries with weak capacity and hence the necessity of Accredited Entities (AEs) as intermediaries. The international climate funds include the Global Environment Facility (GEF), the Green Climate Fund (GCF), the Adaptation Fund (AF) and the funds led by the multilateral development banks (MDBs) such as the Climate Investment Funds and bilateral funds specializing in climate. As a result, the climate finance landscape is diffuse which increases the challenges associated with accessing finance and reduces overall efficiencies.

The government of Kenya has created frameworks and institutions at national and county levels to facilitate and promote access of the country to international climate finance. Through the Climate Finance Policy (2018) and Climate Change Act (2016) establish a framework for a National Climate Change Fund and County Climate Change Funds. In the just ended 2019/2020 Financial Year, and seed money of Ksh 500 million from the National Budget was set aside. In addition, KES 200 million will be allocated in the National Budget annually for a period of five years to operationalize the Climate Change Finance Policy (2018) and to promote green economy low-emission investment and build the country's adaptive capacity.

Green Climate Fund

Kenya has been a beneficiary of the GCF funding. As at end of 2019, Kenya has 11 projects financed by GCF at a cost of US$ 2899.789million with only one project in agriculture that aims at ending drought emergencies through ecosystem based adaptation in Kenya's arid and semi-arid rangelands (TWENDE) (ADA, 2019).

Table 9.2. Projects funded under GCF in Kenya by 2019

Project Name	Accredited Entity	Executing Entity	Project Size (million USD)	Project Area	Status
GCF NAP Readiness Programme	FAO	Min. of Environment & Forestry; National Treasury	3	Kenya	Approved; Disbursed
Global Energy Efficiency and Renewable Energy Fund (GEERF) NeXt	EIB	Ministry of Energy	765	Multi Country	Approved in 2017
KawiSafi Ventures Fund	Acumen Fund Inc.	Acumen Capital Partners LLC.	110	Kenya, Rwanda	35% Disbursed
The Universal Green Energy Access Program (UGEAP)	Deutsche Bank	Ministry of Energy	301.6	Multi-Country	Approved in 2017
Climate Investor One (CIO)	FMO		821.5	Multi-Country	Approved in Nov 2018
Transforming Financial Systems for Climate (TFSC)	AFD		745	Multi-country	Approved in Nov 2018
Promotion of Climate-Friendly Cooking	GIZ	Ministry of Energy	58.8	Kenya, Senegal	Approved in Feb 2019
Towards ending drought emergencies: Ecosystem based Adaptation in Kenya's arid and semi-arid rangelands (TWENDE)	IUCN	Ministry of Agriculture & Irrigation; NDMA	34.5	Kenya	Approved in July 2019
GCF/GIZ Readiness Support	UNDP/WRI/ UNEP	NDA	1.35	Kenya	2015
ARAF	Acumen	Acumen	58.7	Kenya, Nigeria	2018
GCF/PPF	NEMA		0.339	Kenya	2018

Source: ADA, 2019

Global Environment Facility

Global Environment Facility (GEF) mechanism operates three funds: the GEF Trust Fund; the Least Developed Countries Fund (LDCF); and the Special Climate Change Fund (SCCF). The GEF Trust Fund and its Strategic Priority on Adaptation (SPA) supports enabling activities and pilot demonstration projects that address adaptation and at the same time generate global environmental benefits. The GEF has allocated 50 million under the SPA of which 5 million has been devoted to piloting community adaptation initiatives through the Small Grants Programme; The LDCF was partly established to support adaptation projects identified by developed countries by their NAPAs; and The SCCF is partly designed to finance adaptation activities that increase resilience to the impacts of climate change, through a focus on water resources, land, agriculture, health, infrastructure development, disaster preparedness, and fragile ecosystems and coastal zones. Funding is available for establishing pilot projects for wider replicability and integration into national policy and sustainable development planning. The GEF has supported 45 projects in Kenya since its inception in the focal areas of land degradation, biodiversity, climate change and multifocal areas with an estimated value of US$ 762 million. https://www.thegef.org/projects-faceted?f[]=field_p_regionalcountrylist:84.

Adaptation Fund

The Adaptation Fund (AF) finances projects and programmes that help vulnerable communities in developing countries to adapt to climate change. The source of this funding is from a 2% levy on proceeds from CDM projects, as well as from voluntary sources. Initiatives are based on country needs and priorities. NEMA was accredited as the AF and has received funding to the tune of US$10 million for an agriculture project on integrated programme to build resilience to climate change & adaptive capacity of vulnerable communities in Kenya. https://www.adaptation-fund.org/projects-programmes/.

Multilateral and bilateral climate finance

Many multinational and bilateral agencies have established climate change funding mechanisms and initiatives. Examples include: the World Bank (Clean Technology Fund, Pilot Programme for Climate Resilience, Strategic Climate Fund), UNDP (MDG

Achievement Fund – Environment and Climate Change Thematic Review Window, UN-REDD Programme), Government of Japan (Cool Earth Partnership), Government of the United Kingdom (Environmental Transformation Fund – International Window), The European Commission (Global Climate Change Alliance) and Government of Germany (International Climate Initiative). Kenya has and continue to receive bilateral climate finance from several development partners. The bilateral climate finance projects to Kenya by 2019 totals to US ($) 2,359.75 billion of which agriculture projects accounted for only 11.7% of the funds. Some of the major bilateral donors to Kenya include the United Kingdom's Department for International Development (DFID), French Development Agency (AFD), Danish International Development Agency (Danida), German International Development Agency (GIZ), Japan International Cooperation Agency (JICA), Swedish International Development Cooperation Agency (SIDA), Germany's International Climate Initiative and the German government-owned development bank (KfW) (GoK, 2016). Increased bilateral climate finance flows could be attributed to arobust and efficient legal and institutional framework as set out in the Climate Finance Policy (Odhengo *et al.,* 2019).

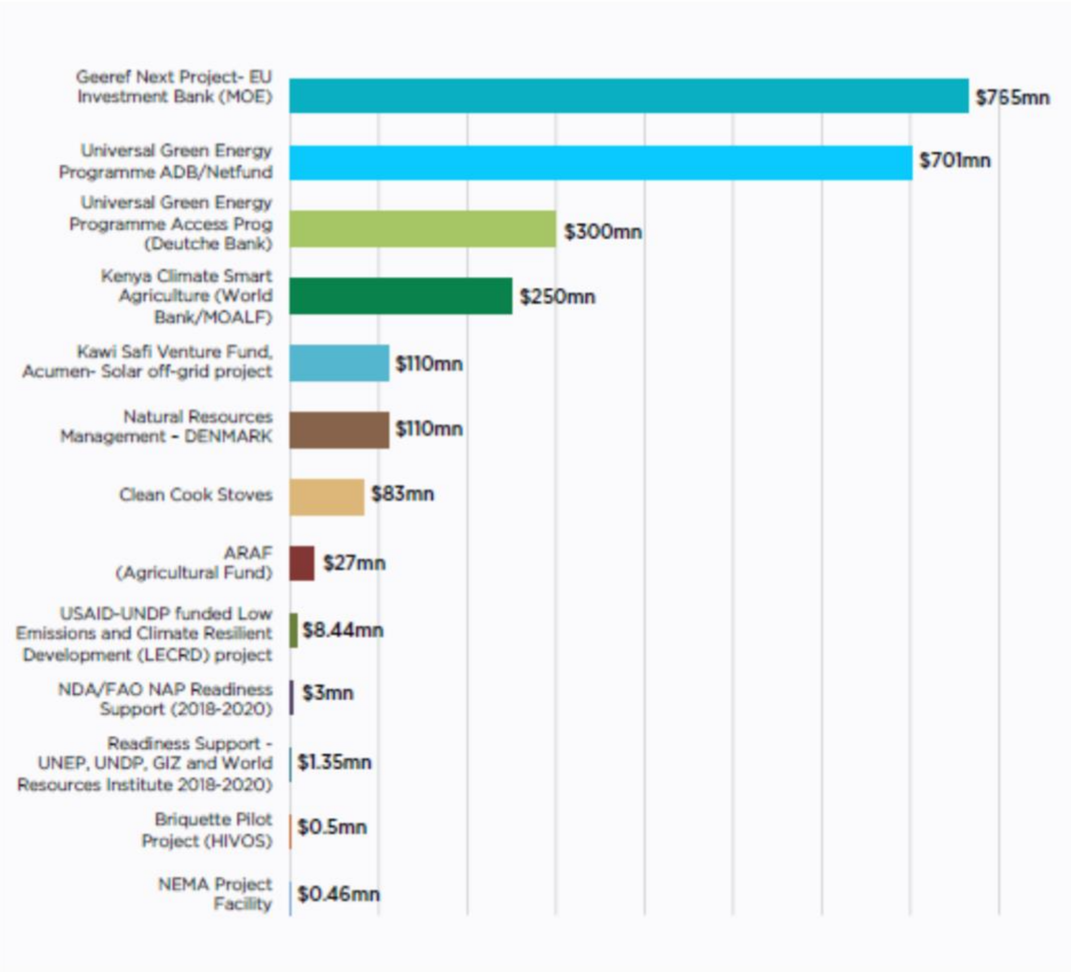


Figure 9.7. Bilateral donor funding in Kenya.

Source: ADA, 2019

Multilateral Development Banks (MDBs)

World Bank

The World Bank has and continues to make investment in Kenya's agriculture sector so as to improve agricultural productivity and build climate resilience. Some of the projects supported by the World Bank are listed in Table 9.3 below.

Table 9.3. World Banks Projects in Agriculture in Kenya, 2000-2019.

Project Title	Commitment Amount in millions (US$)
Kenya Climate Smart Agriculture Project	250.00
National Agricultural and Rural Inclusive Growth Project	200.00
Coastal Region Water Security and Climate Resilience Project	200.00
Kenya Coastal Development Project	35.00
Kenya Agricultural Productivity and Agribusiness Project	82.00
Kenya - Natural Resource Management Project	68.50
Western Kenya CDD and Flood Mitigation Project	86.00
Kenya Arid Lands Resource Management Project Emergency Additional Financing	60.00
Arid Lands Resource Management Project Phase 2	60.00
Total amount	1041.5

The World Bank has also funded other projects in the past such as the Kenya Agricultural Productivity Project (KAPP) that supported agricultural research, extension and farmer empowerment and the Kenya Agricultural Productivity and Agribusiness Project (KAPAP) that aimed to promote agricultural diversification of agriculture, value addition and deepen linkages to markets. More recently, the World Bank has also approved International Development Association (IDA) credit to support the Kenya government's Big Four agenda in which agriculture is prioritized.

African Development Bank

The African development bank has funded 53 projects in Kenya from 2000 to 2018, valued at US$1.9 billion with Agriculture and environment projects accounting for 12% (approximately US$220 million) of the total project budget, energy sector 19%, multi-sector projects at 4% and the transport sector accounting for the largest share of the project at 39% and others2[3] accounting for 26% (Figure 9.8) (www.afdb.org/).

[3] Others refers to Finance and industry, social sector, water supply and sanitation, trust fund and fiscal decentralization support.

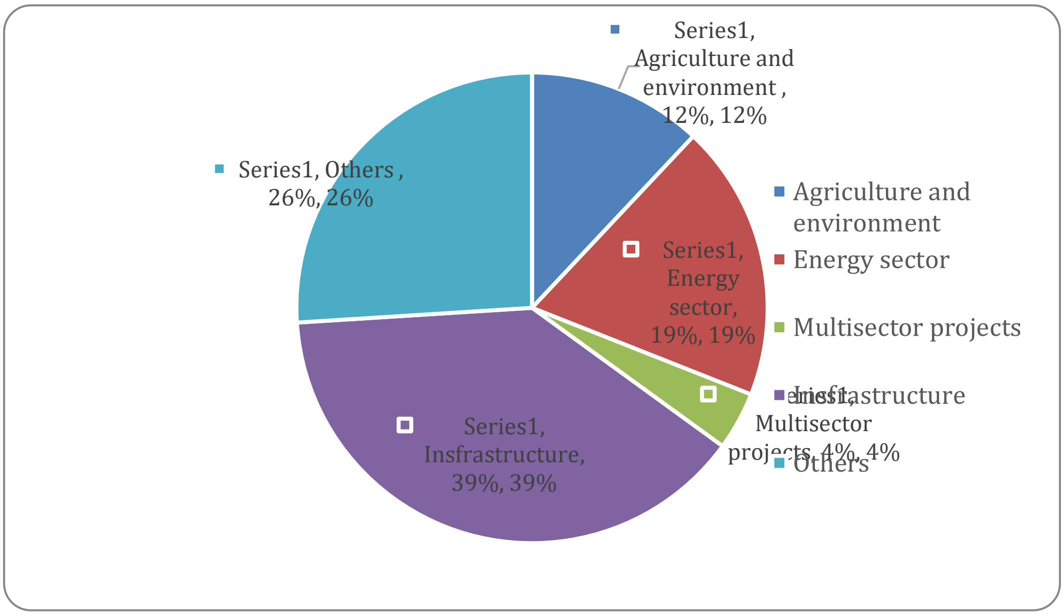


Figure 9.8. African Development Bank Funding to Kenya by sector, 2000 to 2019.

Conclusion and recommendations

Conclusion

Policies, projects and programmes

The agriculture sector in Kenya remains vulnerable to impacts of climate change and adaptation and mitigation plays central to the build resilience and mitigate the impacts of climate change in the agriculture sector. The frameworks and policies that are critical for agriculture and climate change include ASGTS (2018); Kenya Agriculture Strategy (2013), ASDS (2010), NCCAP, 2018 just to mention a few. Despite the implementation and existence of excellent policies on paper, weak practical implementation; limited interaction among experts implementing more or less similar policies; limited policy coherence and coordination across the sub-sectors and related sectors, weak harmonized framework to evaluate the achievement of the policies and strategies. Further, cross cutting issues that determine the growth and progress of the agriculture sector were not explicitly addressed in the policies but rather mentioned as important. This includes gender, youth and climate change. Further, most agriculture policies focus more on increasing household income, increasing agricultural productivity, value addition and market access, and enablers such as capacity building, financing and technology adoption especially in the period 2000 to 2010. During this period, most agriculture sub-sectors implemented adaptation options by default from building social and economic resilience lens rather than climate change. However, co-adaptation benefits have not been adequately explored and most policies have failed to them into their objectives and activities consideration.

Inadequate sustainability mechanisms to ensure continuity of project results upon expiry of projects. This coupled with lack of collaboration and cooperation among project partners and the line ministries has made projects stall upon expiry. Presently, there was no framework to provide periodic updates to the MOAL& F on all projects being undertaken by the different actors under its portfolio. This is critical in consolidating all the efforts under the sector and how they can adequately provide data and information to inform government national and county decision making including regional and international commitments. However, there are upcoming opportunities such as *Multi-stakeholder Platform* coordinated by MOAL&F that aims to strengthen the stakeholder engagement in the management of impacts of climate change and agriculture sector, while allowing actors to free access data and knowledge and information.

Currently, the MoAL&F at the national level has structures in place for monitoring and evaluation with all the state departments of the MoALF having monitoring units. They are however not well linked to provide a ministerial monitoring and evaluation perspective. However, there is inadequate commitment to the M&E culture: many agriculture institutions (public) in Kenya have not embraced the culture of M&E in their policies, strategies programmes and projects implementation. As current state, it is hard to determine whether M&E influences decision making in the ministries, state departments and agencies. An example is the MOALF&C where M&E unit does exist but its functionality is project based, making their operations upon expiry of projects. Similarly, the Forestry Sector has developed a strategy on ensuring the realization of the 10% forest cover but fails to provide a concrete framework for monitoring and evaluation of the proposed strategic interventions in the strategy. There is however disjointed sub-sector level indications of output achievements as a result of efforts by the respective departments.

Kenya has not been able to maximally benefit for the different climate finance instruments due to complexity and beauracratic processes in accessing the funds. This coupled with lack of technical and financial capacity in developing the projects for climate financing. For instance, the many of the projects supported by climate finance are biased towards mitigation with limited supported to vulnerability, adaptation and resilience building. For example in Kenya, most of the climate financed projects are in the energy and transport sector with focus on mitigation.

Recommendations

National government

Kenya need to align its commitments to regional and international commitments as well as cascade the same to the decentralized levels of governance, the counties through county integrated development plans. An example is the aligning of the SDGs, Africa Union Agenda 2063, Malabo Declaration of allocating 10% of the national budget to agriculture and related activities among others to the existing national frameworks. There are enormous opportunities that current exist to help in the alignment. One the Kenya Climate Smart Agriculture Strategy and implementation plan that has not been cascaded to the county levels where the implementation will be carried out to have county climate smart agriculture strategies and plans. Also Agriculture Policy is the pipeline. So far data that to be taken on board are the regional and international commitments that would ensure the mainstreaming of the 2030 Agenda for Sustainable Development and *Africa Agenda 2063.* The National Government through consultations with the Council of Governors prepares and disseminates the guidelines for the preparation of the County Integrated Development Plans (CIDPs) which sub national government should follow to ensure policy and developmental coherence. The CIDPs mirror the priorities of the MTPs at the sub national level and therefore will ensure the SDGs, Africa Agenda 2063 and Malabo declaration among others are mainstreamed at the sub national level including data on women, youth in agriculture, post harvest losses. This is an opportunity that the Multi-stakeholder Platform can take lead and coordinate at national and county levels.

Cascading the best practice national agricultural management in research activities to the county level. A bottom-up, participatory municipal level approach can inform national adaptation and mitigation planning: The inception meeting involved all major relevant stakeholders from the beginning of the process. This provided a solid base for data collection, validation and on-going support for the prioritization process. The *Multi-stakeholder Platform* provides an opportunity to achieve this

A need for a legally binding collaboration, coordination and cooperation across relevant ministries and within the state departments. Even though some of level of collaboration and cooperation does exist, it is no legal binding and have no defined structures across the sectors and departments including data management and the the minimum set of indicators for calculation across the sectors. In addition, there is no framework on how the national agriculture functions needs to work with the county governments. Most of the finances to implement the initiatives come outside the ministry, therefore Agriculture ministries at county and national a level to collectively plan for their programmes with clear framework on how they feed into each level. There is need for a more synchronized, coordinated approach to adaptation and mitigation planning in agriculture sector is necessary to prevent delays and duplication of work.

The data collected are inadequate to estimate the indicators, which do not fully align to regional and international frameworks as stipulated in the Malabo Declaration, Africa Agenda 2063 and SDGs. This calls for the need to develop a comprehensive sector-wide standardized approaches and methodologies for data collection, *minimum set of indicators* for performance monitoring and evaluation system that adequately addresses the needs of the different sub-sectors. This am be coordinated by regional institutions such as AGNES, CCAFS etc. that have a wealth of experience on connecting science- policy in many countries in Africa.

National government to coordinate a long term the capacity building framework for supporting counties deliver on integrated agriculture and climate change goals within the sector. Agriculture sector is devolved, but the capacity need to strengthened if the counties were to deliver their agriculture and climate change goals. This includes the

Need for the capacity building to structured, contionus and have a modality of tracking progress over time.

County government

Increase investments in resilience building to climate variability especially the safety net programmes, value addition along the value chain, management of pre-post harvest losses of farm products. Promote an agriculture value chain with strong private partnership linkage to small holder kick-start innovation and promote commercialization.

Given the diversity of the different landscape, it is important to integrate agro-ecology principles in the sub-sector and production systems based approaches to planning and budgeting for adaptation and mitigation. As at now the policies have generalized programmes and activities for the sub-sectors without taking into consideration the diversity of the different agro-ecological zones.

Kenya Agriculture provides a unique opportunity in reduction of green house gas emissions that have co-benefits to adaptation should be prioritized such as agroforestry, conservation agriculture and feed management in both livestock and fisheries. Also, the coordination and tracking mechanisms for climate finance are weak, thus is difficult to monitor progress and the climate finance disbursed for the different interventions for both state and non-state actors.

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Annex

Kenya National budget in relation to agriculture public sector budget

	Kenya national budget	National budget (KES in 100 billion)	Agriculture sector budget (KES billion)
2000	217.72	2.1772	7.19
2001	218.6	2.186	8.7
2002	218.96	2.1896	10.92
2003	240	2.4	15.7
2004	440	4.4	17.6
2005	550.1	5.501	19.1
2006	693.6	6.936	24.6
2007	758.9	7.589	30.3
2008	867.6	8.676	23.9
2009	977	9.77	32.2
2010	998.8	9.988	38.2
2011	1155	11.55	33.3
2012	956.9	9.569	50.4
2013	1641	16.41	38.1
2014	1433.2	14.332	38.066
2015	1506	15.06	37.4
2016	1667	16.67	69.9
2017	2290	22.9	41
2018	3000	30	45
2019	3200	32	52

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